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Attitudes, Knowledge, and Implementation of Biotechnology and Agriscience
by West Virginia Agricultural Education Teachers

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Thesis submitted to the
College of Agriculture, Forestry and Consumer Sciences
at West Virginia University
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in
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ABSTRACT

Attitudes, Knowledge, and Implementation of Biotechnology and Agriscience
by West Virginia Agricultural Education Teachers

Jason E. Hughes

The purpose of this study was to provide information on the attitudes toward and knowledge level of biotechnology and agriscience as well as activities conducted which demonstrate implementation of biotechnology and agriscience by West Virginia Agricultural Education teachers.

Data was collected via a questionnaire. Knowledge level, teaching methods used, attitudes of the subject and teaching responsibilities, barriers to teaching, and preferred information sources of biotechnology and agriscience were the major parts. Demographics and level of science knowledge were other parts of the questionnaire.

A major finding of the study was that West Virginia agricultural education teachers possess a positive attitude towards biotechnology, but lack some of the resources and knowledge to incorporate the subject matter into their curriculum. The teachers possess a positive attitude about agriscience, but feel that agriscience classes should not be the only classes taught in an agricultural education program.

DEDICATION

To Mom, Dad, and Grandma Hughes, thank you for always believing in me and for instilling in me a strong work ethic. I love you.

To my four wonderful babies, Lakyn, Logan, Michaela, and Lane, you have shown me that life is not just about me. I love you.

To my lovely and talented wife, Carrie, thank you for always standing behind me and supporting me even when it was not easy. I will always love you.

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Thank you JESUS for always having my best interest in mind. Your timing is always just right!

I would like to express my appreciation to all of the agriculture education teachers who participated in the survey. Without their participation, the study could not have been successfully completed.

To Dr. Gartin, thank you for being a great advisor and most of all, a friend. You have always looked out for me, and for that, I am grateful. To Dr. Boone, your efficiency amazes me. Thank you for your assistance on crunching the numbers and caring about this thesis and for me. To Dr. Lawrence, thank you for your time and wisdom. To Dr. Odell, thank you for being there for me throughout my years of education. Dr. Daily, thank you for agreeing to be on my committee and helping all teachers throughout the year.

To Don Stephens, Keith Burdette, Don Michael, and Ron Grimes, you are men who I consider having a major impact on my life's choice to be a teacher. Thank you for being great teachers.

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CHAPTER I

INTRODUCTION

Science related competencies have always been a part of the agricultural education curriculum. Concepts and principles of chemistry, biology, genetics, physiology, and zoology are readily applied to plant and animal studies (Moss, 1985). Martin (1989) stated that, " Although sciences pertinent to agriculture are being taught, we do not know to what extent they are being taught nor do we know what is being taught and what more should be taught related to the sciences of agriculture" (p. 244).

Agriscience, bioscience, and ag-technology are all buzzwords currently being used to reflect infusion of biotechnology and genetic engineering into the agricultural education curriculum. Biotechnology involves the biology and chemistry of living organisms at the cellular level. Genetic engineering involves the transferring of genes from one organism to another. Both are having major impacts on the agricultural industry and the consumers of agriculture in this nation (National Council on Vocational Education, 1990).

According to the National Council on Vocational Education, the concern for integrating more science and technology into the agricultural curriculum has been spurred by four movements: a) the national back-to-basics emphasis on math and science; b) the national study on agricultural education in the United States which indicated that "the subject matter about agriculture and in agriculture must be broadened," this said by the National Research Council; c) the expressed need by industry for employees to be able to solve problems and think more

critically, and d) the rapid pace by which agriculture is changing as a result of technological

advances (Kirby, 1990, p. 71). Smith as cited by Martin (1989) raised the following point:

>Many educators question what needs to be taught in the sciences related to agriculture. How
>
>much science should be taught in vocational agriculture programs? Is biotechnology
>
>likely to have an impact that would warrant a specialized curriculum effort? Should
>
>information on biotechnology be integrated into all aspects of the agriculture curricula?
>
>(p. 244)

Agricultural educators in West Virginia are faced with the challenge of teaching about

developing technologies in agriculture. The need for more science electives being offered at the

high school level has created the need for a versatile agricultural educator with strong preparation

in, and knowledge of, science and agriculture. So that West Virginia agricultural educators will

be prepared to deliver a more in-depth science curriculum to their students, it is important to

assess the attitudes of West Virginia agricultural teachers, knowledge, and strategies for using

agriculture as a means to convey these important science concepts and techniques.

Purpose and Objectives

The purpose of the study was to provide information to the state supervisor of agricultural

education and teacher educators that may be useful in modifying undergraduate course

requirements and in planning in-service workshops and graduate courses to enhance teacher

knowledge.

The primary objective of this study was to describe the attitudes of West Virginia

agricultural education teachers toward and knowledge level of biotechnology and agriscience as

well as activities that demonstrate implementation of biotechnology and agriscience. A secondary

objective was to determine if there were relationships between selected demographic teacher variables and agriscience attitudes and knowledge levels.

Research Questions

The following questions provided direction for the study:

1. What are the attitudes of West Virginia agricultural education teachers toward biotechnology and agriscience?

2. What level of knowledge and understanding is demonstrated by West Virginia agricultural education teachers regarding biotechnology and agriscience?

3. What teaching methods do West Virginia agricultural education teachers use when teaching biotechnology and agriscience?

4. What is the perceived role of the agricultural education teacher with regard to biotechnology?

5. What barriers do agricultural education teachers face when they teach agriscience and biotechnology?

6. What relationships exist between selected teacher demographic variables and biotechnology attitudes and knowledge levels?

7. How do West Virginia Agricultural Education teachers prefer to receive biotechnology and agriscience information?

Definition of Terms

1. <u>West Virginia agricultural education teachers</u> - teachers holding full-time teaching positions in

secondary agricultural programs in West Virginia during the 2000-2001 school year.

2. <u>Biotechnology</u> - general term that refers to engineering living organisms on the cellular level.

3. <u>Agriscience</u> - the inclusion of science concepts in agriculture.

4. <u>Genetic engineering</u> – changing the genetic information in a cell, resulting in a transgenic

organism.

Limitations of the Study

This study was limited to West Virginia Agricultural Education teachers employed during

the 2000-2001 school year.

CHAPTER II

REVIEW OF LITERATURE

Origins of Agriscience

The Smith-Hughes Act established secondary agriculture education in the United States in 1917. The act was designed to encourage states to promote and further develop programs of vocational education which otherwise might not be adequately provided in our state systems of education. This act provided for vocational education in agriculture, trades and industries, and homemaking (Phipps, 1988).

Before the passage of the Smith-Hughes Act of 1917, there was the Hatch Act of 1887. The Hatch Act gave American agriculture true experimentation and scientific research. There is a direct cause and effect line that can be drawn from the Hatch Act funded research findings and the establishment of the cooperative extension service that helped distribute such findings to the practitioner farmer. Can Hatch Act influence be found as directly with the early agricultural education movement? Was early agricultural education more scientifically based that the contemporary version? (Hillison, 1996, p. 8)

One of the significant national issues in agricultural education today is the role agriscience should play in middle school and high school curricula (National Research Council, 1988). "All students need an understanding of basic science concepts. Teaching science through agriculture would incorporate more agriculture into curricula while more effectively teaching science" (National Research Council, 1988, p. 11).

Hillison (1996) raises a few questions about agriscience: "Just where did this idea of agriscience come from? What has been the evolutionary development of the program? Does it fit into a basic vocational program? Is agriscience really more academic than vocational (p. 8)?

According to Hillison (1996), two years after the passage of Hatch Act, Chamber's Encyclopedia had a definition of agricultural education that showed thinking similar to the Act. The definition used for the field was:

> Agricultural Education, as at present understood, is a comprehensive term, including instruction in chemistry, geology, botany, zoology, mechanics embracing, in short the science as well as the practice of agriculture. However important branching off of education into this special track, it is only of late years that adequate attention has been paid to it. (p. 10)

Twenty-eight years after the Chamber's Encyclopedia definition of agricultural education, the Smith-Hughes Act had a different definition, according to Hillison (1996):

> …any State shall provide in its plan for agricultural education that such education shall be that which is under public supervision or control; that the controlling purposes of such education shall be to fit for useful employment; that such education shall be of less than college grade and be designed to meet the needs of persons over fourteen years of age who have entered upon or who are preparing to enter upon the work of the farm or of the farm home. (p. 10)

"Obviously the Smith-Hughes Act shifted the definition of agricultural education from being science-based and academic-oriented to a strictly vocational definition (Hillison, 1996, p. 10).

Over 100 years ago the Hatch Act used the words agricultural science. With the Act's

emphasis on sophisticated research, agriculture became a leader in scientific research.

With this kind of attention and support from the agricultural community, early

agricultural education was considered an academic and scientific course of study. After

the passage of the Smith-Hughes Act, agricultural education joined other vocational

oriented instruction and de-emphasized academic instruction. However, the basic science

base for the field of agriculture has not changed. (Hillison, 1996, p. 11, 12)

<u>Agriscience Today</u>

Buriak, as cited by Dormady (1993, p. 63) defined agriscience as "instruction in

agriculture emphasizing the principles, concepts, and laws of science and their mathematical

relationships supporting, describing, and explaining agriculture."

Ongoing efforts should be expanded and accelerated to upgrade the scientific and

technical content of vocational agriculture courses. The "vocational" label should be

avoided to help attract students with diverse interests, including college bound and those

aspiring to professional and scientific careers in agriculture. Agricultural courses

sufficiently upgraded in science content should be credited toward satisfying college

entrance and high school graduation requirements for science courses in addition to the

core curriculum.(National Research Council, 1988, p. 35)

Haye (1980) states, " If instruction in agriculture is to take its rightful place in curriculum,

it should be regarded as a science and not as a vocational subject for students who cannot cope

with the sciences (p. 20).

According to Terry (1993), "The agriscience curriculum calls for something different. While FFA and Supervised Agricultural Experience (SAE) are essential parts of a total educational experience, they are of lesser importance and are more an opportunity to apply what is learned in the classroom/laboratory rather than the focus of the entire program" (p. 9).

There are a lot of similarities between teaching "regular" science (e.g., biology, chemistry, physics) and agriscience. Therein lies a potential problem. While we see a big difference between a program such as agricultural education and a course such as chemistry, others may not. With the trend toward semester courses in agricultural education, it is very easy for an administrator, at both the local and state level to view "regular" science courses and agriscience courses as being basically the same. Thus, it becomes logical to think that the chemistry teacher or the biology teacher, as well as the agriculture teacher can teach agriscience. Agriscience faces the potential danger of becoming absorbed within the science curriculum as a class rather than remaining a separate, distinct program (Vaughn, 1993).

Osborne (1993) states,

And clearly, we must focus on redefining the place and role of agricultural education in the secondary schools. But at the same time, it would be a drastic mistake to throw away *everything* from the past and start from scratch. We should continue to teach technical skills, job skills, entrepreneurship, and leadership skills. We should continue to teach how to grow plants and raise animals. We should continue to teach agricultural mechanics. But we should teach these topics better by linking the practices of agriculture with the science of how plants and animals grow; how machines work; and why plants, animals, and materials respond to treatments as they do. The result will be a stronger agriculture

curriculum, a student who makes better management decisions in plant and animal

agriculture, and a student who has a working knowledge of science. The right kind of

agriscience instruction will make the agriculture program stronger, while making a unique

contribution to the scientific literacy of students in the school.(p. 3)

<u>Biotechnology</u>

Rapidly evolving technologies have always pressured agricultural educators to keep

abreast of developments and create relevant curricula. Biotechnology is no exception.

Biotechnology is the procedures used to influence living things at the cellular level to produce

commercial products. The techniques of biotechnology range from genetic engineering to

fermentation, and they are among the most complex and widely applied innovations of our time.

Biotechnology is already applied to agriculture in more ways than most of us suspect (Smith,

1989).

According to Lasley, "Biotechnology is a buzz word commonly heard in conversation

today, but seldom understood beyond the realm of science. Yet biotechnology is being called

agriculture's third wave, comparing it to machines replacing human labor and chemicals being

introduced into agricultural production" (Martin, 1989, p. 243).

"Biotechnology with all its inherent complexities, mysteries, problems, and challenges,

promises to revolutionize farming and agriculture. In addition, it is expected to become the major

source of innovation for agriculture by the early 21st century", according to Hardy as cited by

(Martin, 1989, p. 243).

According to Martin (1989),

Biosciences such as plant science, animal science, genetics, microbiology, soil science,

and food science provide the foundation for the growth and development of the industry

of agriculture. The application of biotechnology must be shared with students of

agriculture in order to educate them regarding the occupation available in the field.

The study of biosciences paves the way for thorough preparation for students by laying

down a strong foundation in the principles and concepts of science over which a super

structure of agricultural biotechnology can be built in the years to come.(p. 243)

Martin (1989) goes on to say,

There exists a perception among some agriculture instructors that vocational agriculture

tudents are not very interested in learning the biosciences related to agriculture. This

finding might be attributed to the fact that the instructors were concerned that too much

focus on the sciences of agriculture may hurt enrollment instead of enhance enrollment in

agriculture programs. (p. 246)

According to Pool (1988),

The teachers who provide instruction in production agriculture only in today's classroom

are lost and have surely signed the death warrant for their programs. Today's instruction

must reflect what is coming in the future, not what has been in the past. Look at the

students in our programs and find out how many are actually living on a production farm.

I suggest that if the only students you have in your program are those interested in

production agriculture, you have already lost sight of where you need to be. The

curriculum of tomorrow's program must be inviting to those students who are interested

in all fields of agriculture, including agricultural related business. (p. 9)

4-H leaders and agriculture education teachers are already introducing biotechnology to future farmers. Through the Carl Perkins Vocational Education Act, the United States Congress appropriated funds to help vocational students learn about new technologies. New curricula will likely emphasize career awareness because biotechnology is creating many unexpected opportunities. It will also emphasize the impact of biotechnology on the international agricultural economy. Other areas of emphasis are the impact of biotechnology on the environment, energy, and resource conservation (Smith, 1989).

Smith (1989), feels that,

The need to learn about biotechnology extends from high school students to legislators, and the gap between agriscience and agriculture is narrowing. Through genetic engineering, today's tobacco farm could become tomorrow's factory producing raw materials for pharmaceuticals. As a result, the education of tomorrow's agriculture worker will become more complex and more interesting. High school vocational agricultural courses could begin to hold more interest for academic students interested in biochemistry and genetics.(p. 11)

CHAPTER III

METHODOLOGY

<u>Purpose and Objectives</u>

The purpose of the study was to provide information to the state supervisor of agricultural education and teacher educators that may be useful in modifying undergraduate course requirements and in planning in-service workshops and graduate courses to enhance teacher knowledge.

The primary objective of this study was to describe West Virginia agricultural teachers' attitudes toward and knowledge level of biotechnology and agriscience as well as activities that demonstrate implementation of biotechnology and agriscience. A secondary objective was to determine if there were relationships between selected demographic teacher variables and agriscience attitudes and knowledge levels.

<u>Research Design</u>

A descriptive survey research method was used to collect data from high school agricultural education instructors in West Virginia. "Descriptive research is not generally directed toward hypothesis testing. The aim is to describe, "what exists" with respect to variables or conditions in a situation" (Ary, 1990, p. 381). It is the aim of this research to discover "what exists" among West Virginia agricultural education teachers in the areas of biotechnology and agriscience.

"Descriptive surveys focus on determining the status of a defined population with respect to certain variables. They basically inquire into the status quo; they attempt to measure what

exists without questioning why it exists" (Ary, 1990, p. 407). This design is appropriate for determining the knowledge level, attitudes, and implementation of the study population.

Population of the Study

The population for the study included the 95 agricultural education teachers from West Virginia during the 2000-2001 school year. The population frame was established from the 2000-2001 West Virginia Secondary Agriculture Teachers Directory.

Instrumentation

A survey was mailed to all agricultural education instructors in the state of West Virginia. The survey was organized into three major sections. Section I focused on biotechnology and had three parts. The perceived level of knowledge and teaching methods used in biotechnology was the first part. The attitudes that teachers possess on biotechnology issues and teaching biotechnology made up the second part. The third part of this section rated the implementation of biotechnology by looking at barriers and how teachers gather information.

Section II focused on agriscience and consisted of three parts. The perceived level of knowledge and teaching methods used in agriscience and the level of knowledge that teachers possess about general science subjects made up the first first part. The attitudes that teachers possess on agriscience issues and teaching agriscience made up the second part. The third part of this section rated the implementation of agriscience looking at barriers and how teachers gather information.

Section III requested demographic information including: years of experience, highest degree held, ownership of a farm, and ownership of an agribusiness.

The questionnaire was constructed according to recommendations by Dillman (1978) and Sudman and Bradurn (1982). These include recommendations on question ordering and the color of the paper.

An existing study and instrument conducted by Kirby (1990) in North Carolina was modified for this investigation. The revised instrument was presented to a panel of experts consisting of teacher educators at West Virginia University to establish content and face validity.

A panel of experts, consisting of agricultural education teachers serving on the West Virginia Program and Policy committee, was used to pilot test the instrument. They were administered the questionnaire and the data were used to establish the instrument's reliability. Cronbach's alpha is the most widely used and appropriate reliability tool. The reliability of the instrument was found to be .9026.

<u>Data Collection</u>

Dillman's suggestions for constructing survey instruments, cover letters, and follow-up strategies were implemented (1978). A survey with cover letter was mailed to each of the agricultural education teachers in West Virginia. A stamped, self-addressed envelope was provided for return of the instrument. A follow-up letter was sent two weeks after the original to remind those who had not yet responded that their cooperation was essential.

Non-response was examined by comparing late respondents to early respondents (Smith and Miller, 1983). Late respondents have been shown to be similar to non-respondents.

<u>Analysis of Data</u>

This study sought to measure the knowledge level, attitudes, and implementation of WV agricultural education teachers in the areas of biotechnology and agriscience. Data collected were analyzed using SPSS at West Virginia University. Descriptive analyses were performed on the data, which are presented in narrative and tabular form.

CHAPTER IV

FINDINGS

The purpose of the study was to provide information to the state supervisor of agricultural education and teacher educators that may be useful in modifying undergraduate course requirements and in planning in-service workshops and graduate courses to enhance teacher knowledge. To accomplish this purpose, 95 West Virginia (WV) agricultural education teachers were surveyed. Teachers were surveyed to ascertain their knowledge, attitudes, and implementation of biotechnology and agriscience.

The primary objective of this study was to describe West Virginia agricultural education teachers' attitudes toward and knowledge level of biotechnology and agriscience as well as activities which demonstrate implementation of biotechnology and agriscience. A secondary objective was to determine relationships that exist between selected demographic teacher variables and agriscience attitudes and knowledge levels.

Research Questions

The following questions provided direction for the study:

1. What are the attitudes of West Virginia agricultural education teachers toward biotechnology and agriscience?

2. What level of knowledge and understanding is demonstrated by West Virginia agricultural education teachers regarding biotechnology and agriscience?

3. What teaching methods do West Virginia Agricultural Education teachers use when teaching biotechnology and agriscience?

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4. What is the perceived role of the agricultural education teacher with regard to Biotechnology?

5. What barriers do agricultural education teachers face when they teach agriscience and biotechnology, concepts and problems?

6. What relationships exist between selected teacher demographic variables and biotechnology attitudes and knowledge levels?

7. How do West Virginia Agricultural Education teachers prefer to receive biotechnology and agriscience information?

Instrument

Responses of West Virginia agricultural education teachers are summarized in the following pages. Results of the data analysis are presented in the following areas: demographics of the sample group; frequency, mean, and standard deviation of biotechnology and agriscience knowledge, teaching method used, attitudes, and implementation; frequency and percent of biotechnology and agriscience knowledge, attitudes, and implementation; and relationships between biotechnology and agriscience knowledge, attitudes, and implementation and key demographic areas.

Data obtained were analyzed at West Virginia University using the Statistical Package for Social Sciences for Windows (SPSS). Data were analyzed using frequencies, percentages, means, Kendall's tau-c coefficient and Cramer's V coefficient.

Demographics of the Sample Group

The population of this study consisted of WV agricultural education teachers employed during the 2000-2001 school year. The teachers were asked how many years they had taught,

what was the highest degree they held, if they lived on a farm, if they owned an agribusiness, and what were the courses they were currently teaching.

<u>Instrument Reliability</u>

An existing study and instrument conducted by Kirby (1990) in North Carolina was modified for this investigation. The revised instrument was presented to a panel of experts consisting of teacher educators at West Virginia University to establish content and face validity.

A panel of experts, consisting of agricultural education teachers serving on the West Virginia Program and Policy committee, was used to pilot test the instrument. They were administered the questionnaire and the data were used to establish the instrument's reliability. Cronbach's alpha is the most widely used and appropriate reliability tool. The reliability of the instrument was found to be .9026.

Non-response error was examined by comparing late respondents to early respondents (Smith and Miller, 1983). Late respondents have been shown to be similar to non-respondents. No statistically significant differences between the responses of early and late respondents were found.

<u>Key Demographic Areas</u>

Information was received from 62 teachers, as noted on Table 1 and Table 2. Of the teachers reporting, the mean for years taught was 16. When asked what was their highest degree earned the respondents indicated that 31 (50%) held a B.S. degree, 29 (46.8%) held a M.S. degree, and 1 (1.6%) held a Ph.D. Among the respondents, 40 (64.5%) operated a farm and 14 (22.6%) owned an agribusiness.

Table 1

Demographic Characteristics (n=62)

Variable	f	M	SD
Years Taught	62	16	9.95

Table 2

Demographic Characteristics (n=62)

Variable	f	%
Highest Degree		
BS	31	50.0
MS	29	46.8
PhD	1	1.6
Operate a Farm		
Yes	40	64.5
No	22	35.5
Operate an Agribusiness		
Yes	14	22.6
No	48	77.4

Biotechnology Level of Knowledge

The level of biotechnology knowledge reported by teachers can be found in Table 3.

Animal reproduction (M=3.67) was the only topic area that teachers indicated that they had

"applied, knowledgeable." Eleven areas of biotechnology; growth hormones (M=3.14),

hybridization (M=3.02), resistant plant species (M=3.00), plant tissue culture (M=2.98),

biotechnology ethics (M=2.93), cloning (M=2.90), genetic modified food (M=2.83), genetic

engineering (M=2.81), food biotechnology (M=2.62), environmental biotechnology (M=2.60),

and gene splicing (M=2.57) had means between 2.51 and 3.50, indicating that WV agriculture

education teachers had "read about, possess some knowledge" about these topics. Five

biotechnology topics had means score between 1.51 and 2.50. These areas, indicating that

teachers had "heard about, but had very little knowledge," were microbial biotechnology

(M=2.41), recombinant DNA (M=2.38), transgenic species (M=2.16), and electrophoresis

(M=2.05). Bioremediation (M=1.67) had a mean lower than 2.00, which indicates the WV

agricultural education teachers have "no knowledge" of this topic area.

Table 3

Means and Standard Deviations for Biotechnology Knowledge (n=62)

Topics	f	M	SD
Animal Reproduction.	57	3.67	0.64
Growth Hormones (bST, pST)	58	3.14	0.81
Hybridization	57	3.02	0.94
Resistant plant species	58	3.00	0.77
Plant Tissue Culture	55	2.98	0.87
Biotech. Ethics	57	2.93	0.73
Cloning	60	2.90	0.68
Genetically modified food	60	2.83	0.76
Genetic engineering	59	2.81	0.71
Food Biotechnology	60	2.62	0.87
Environmental Biotech.	60	2.60	0.85
Gene Splicing	60	2.57	0.75
Microbial Biotechnology	58	2.41	0.94
Recombinant DNA	60	2.38	0.90
Transgenic species	56	2.16	0.83
Human Genomics	57	2.10	0.82
Electrophoresis	59	2.05	1.02
Bioremediation	60	1.67	0.80

1=No knowledge
2=Heard about, but very little knowledge
3=Read about, possess some knowledge
4=Applied, knowledgeable

The number and percentage of agricultural education teachers reporting the level of their

knowledge in eighteen areas of biotechnology is reported in Table 4. In five areas, over 50% of

the teachers had "read about, possess some knowledge" of the subject. Those topic areas were:

genetic engineering, cloning, genetically modified food, environmental biotechnology, and food

biotechnology. At 67.7%, animal reproduction was the only topic in which more than 50% of the

agriculture education teachers were "applied, knowledgeable." The majority of the agricultural

education teachers reported that they had "heard about, but had very little knowledge" about most

of the biotechnology areas.

Table 4

Frequencies of Biotechnology Knowledge

Topics	No Knowledge		Little Knowledge		Some Knowledge		Knowledge-able	
	f	%	f	%	f	%	f	%
Recombinant DNA	12	19.4	18	29.0	25	40.3	5	8.1
Bioremediation	30	48.4	22	35.5	6	9.7	2	3.2
Gene Splicing	4	6.5	23	37.1	28	45.2	5	8.1
Genetic Engineering	2	3.2	15	24.2	34	54.8	8	12.9
Cloning	2	3.2	11	17.7	38	61.3	9	14.5
Transgenic species	12	19.4	26	41.9	15	24.2	3	4.8
Genetically modified food	4	6.5	11	17.7	36	58.1	9	14.5
Electrophoresis	22	35.5	19	30.6	11	17.7	7	11.3
Environmental Biotech.	8	12.9	14	22.6	32	51.6	6	9.7
Food Biotechnology	9	14.5	11	17.7	34	54.8	6	9.7
Microbial Biotechnology	11	17.7	19	30.6	21	33.9	7	11.3
Hybridization	5	8.1	9	14.5	23	37.1	20	32.3
Plant Tissue Culture	4	6.5	9	14.5	26	41.9	16	25.8
Resistant plant species	2	3.2	11	17.7	30	48.4	15	24.2
Animal Reproduction	1	1.6	2	3.2	12	19.4	42	67.7
Growth Hormones (bST/pST)	2	3.2	9	14.5	26	41.9	21	33.9
Human Genomics	14	22.6	25	40.3	16	25.8	2	3.2
Biotechnology Ethics	1	1.6	14	22.6	30	48.4	12	19.4

1=No knowledge
2=Heard about, but very little knowledge
3=Read about, possess some knowledge
4=Applied, knowledgeable

<u>Biotechnology Teaching Methods Used</u>

      As indicated in Table 5, 40% of the teachers reported that they did not teach nine of the eighteen (50%) biotechnology topics. When topics were taught, they were taught using lecture/discussion 36% of the time. Demonstrations were used to teach the biotechnology topics only 10% of the time. It was also noted that only 10% of the time were students applying biotechnology or problem solving.

Table 5

Frequencies of Biotechnology Teaching Methods by Respondents

Topics	Don't Teach		Lecture/Disc.		Demonstration		Student Applied		Problem Solving	
	f	%	f	%	f	%	f	%	f	%
Recombinant DNA	37	59.7	20	32.3	2	3.2	3	4.8	5	8.1
Bioremediation	54	87.1	2	3.2	2	3.2	1	1.6	1	1.6
Gene Splicing	30	48.4	2	3.2	2	3.2	2	3.2	1	1.6
Genetic Engineering	21	33.9	36	58.1	2	3.2	2	3.2	3	4.8
Cloning	20	32.3	32	51.6	5	8.1	5	8.1	6	9.7
Transgenic species	41	66.1	13	21.0	1	1.6	3	4.8	1	1.6
Genetically modified food	22	35.5	33	53.2	2	3.2	9	14.5	2	3.2
Electrophoresis	45	72.6	9	14.5	1	1.6	1	1.6	1	1.6
Environmental Biotech.	27	43.5	25	40.3	3	4.8	6	9.7	9	14.5
Food Biotechnology	26	41.9	24	38.7	8	12.9	8	12.9	5	8.1
Microbial Biotechnology	42	67.7	17	27.4	3	4.8	3	4.8	1	1.6
Hybridization	19	30.6	29	46.8	9	14.5	12	19.4	10	16.1
Plant Tissue Culture	22	35.5	26	41.9	13	21.0	11	17.7	10	16.1
Resistant plant species	21	33.9	25	40.3	9	14.5	9	14.5	10	16.1
Animal Reproduction	9	14.5	29	46.8	16	25.8	17	27.4	20	32.3
Growth Hormones (bST/pST)	21	33.9	28	45.2	9	14.5	10	16.1	7	11.3
Human Genomics	45	72.6	12	19.4	3	04.8	3	04.8	2	03.2
Biotech. Ethics	19	30.6	35	56.5	2	03.2	9	14.5	10	16.1

Relationships Between Key Demographic Areas and Biotechnology Knowledge

The biotechnology knowledge reported by teachers was correlated with the key demographic areas. Table 6 displays the correlation between the eighteen biotechnology knowledge topics and the demographics areas of years of experience, owning a farm, owning an agribusiness and degree held.

The following scale was used to describe the magnitude of relationship between variables (Davis, 1971).

Coefficient Description

.70 or higher	Very strong association (relationship)
.50 to .69	Substantial association
.30 to .49	Moderate association
.10 to .29	Low association
.01 to .09	Negligible association

As indicated in Table 6, there was a negligible relationship (Kendall's tau-c) between years of teaching experience and thirteen of the eighteen biotechnology topics. A low relationship (Kendall's tau-c) existed between years of teaching experience and human genomics (.21), transgenic species (.20), microbial biotechnology (.18), environmental biotechnology (.16), and electrophoresis (.10). The topic of human genomics was significant at the .05 level. Thirty-two percent of the teachers with twelve years of teaching experience or less tended to have no knowledge of the subject, while, 46% of the teachers with over twelve years of experience had at least read about human genomics and had some knowledge.

There was a negligible relationship (Cramer's V) between owning a farm and the topics

of genetically modified food (.08) and gene splicing (.07). There existed a low relationship (Cramer's V) between eleven of the eighteen biotechnology topics and owning a farm. A moderate relationship (Cramer' V) existed between owning a farm and the topics of human genomics (.35), biotechnology ethics (.33), food biotechnology (.33), and hybridization (.30). A substantial relationship (Cramer's V) existed between owning a farm and the topic of growth hormones (.50). The topic of growth hormones was significant at the .05 level. Fifty-three percent of the agricultural education teachers that owned a farm reported that they had applied and were knowledgeable about growth hormones.

There was a low relationship (Cramer's V) between owning an agribusiness and twelve of the eighteen biotechnology topics. There was a moderate relationship (Cramer's V) between owning an agribusiness and animal reproduction (.38), transgenic species (.37), environmental biotechnology (.33), biotechnology ethics (.33), and hybridization (.31). Bioremediation and animal reproduction were significant at the .05 level. Sixty-four percent of those that did own an agribusiness had no knowledge of bioremediation. Forty-five percent of those that did not own an agribusiness had no knowledge of bioremediation. Ninety-two percent of those that did own and agribusiness had applied and were knowledgeable about animal reproduction.

There was a low relationship (Cramer's V) between highest degree held and bioremediation (.29), growth hormones (.28), animal reproduction (.27), resistant plant species (.18), and human genomics (.17). There was a moderate relationship (Cramer's V) between nine of the eighteen biotechnology topics and highest degree held. There was a substantial relationship (Cramer's V) between highest degree held and transgenic species (.57), recombinant DNA (.52), gene splicing (.52), and electrophoresis (.50).

The topics of: recombinant DNA, gene splicing and transgenic species were significant at

the .01 level. Electrophoresis was significant at the .05 level. Forty-eight percent of the teachers that held a master's degree or PhD had some knowledge or were knowledgeable about recombinant DNA. Fifty-seven percent of teachers with a bachelor's degree had some knowledge or were knowledgeable about gene splicing. Forty-eight percent of teachers with a bachelor's degree and with a master's degree had heard about but possessed very little knowledge of transgenic species. Fifty percent of master's degree teachers had heard about electrophoresis and forty-five percent of the teachers with bachelor's degrees had no knowledge.

Table 6

Relationships Between Key Demographic Areas and Biotechnology Knowledge

Topics	Years Exp. (Kendall's tau-c)		Own Farm (Cramer's V)		Own Agribusiness (Cramer's V)		Degree Held (Cramer's V)	
Recombinant DNA	0.05		0.27		0.14		0.52	**
Bioremediation	0.02		0.25		0.41	*	0.29	
Gene Splicing	-0.06		0.07		0.21		0.52	**
Genetic Engineering	0.00		0.21		0.16		0.42	
Cloning	-0.11		0.14		0.13		0.41	
Transgenic species	0.20		0.12		0.37		0.57	**
Genetically Modified Food	-0.11		0.08		0.22		0.36	
Electrophoresis	0.10		0.23		0.29		0.50	*
Environmental Biotech.	0.16		0.19		0.33		0.41	
Food Biotechnology	0.06		0.33	*	0.29		0.44	
Microbial Biotechnology	0.18		0.24		0.27		0.44	
Hybridization	-0.17		0.30		0.31		0.30	
Plant Tissue Culture	0.00		0.23		0.27		0.40	
Resistant Plant Species	-0.13		0.27		0.22		0.18	
Animal Reproduction	-0.15		0.24		0.38	*	0.27	
Growth Hormones (bST/pST)	-0.06		0.50	**	0.14		0.28	
Human Genomics	0.21	*	0.35		0.25		0.17	
Biotech. Ethics	0.07		0.33		0.33		0.30	

* = significant at .05 level
** = significant at .01 level

Biotechnology Classes/Workshops

On average, the population of agriculture educators had attended less than one

biotechnology classes/workshops (.82). Fifty-three percent of the agricultural education teachers

had never taken a biotechnology class or workshop. Thirty-two percent had attended one class or

workshop. Fourteen percent of the teachers had attended between two and six biotechnology

classes or workshops.

Teachers were asked to express the degree of agreement or disagreement with ten attitudinal statements about biotechnology. The mean responses to those statements are reported in Table 7.

Table 7

Means and Standard Deviations for Biotechnology Attitudes (n=62)

Topics	n	M	SD
Cloning living organisms is morally wrong.	61	2.75	0.79
Cross breeding to produce hybrids is morally wrong.	62	3.13	0.97
I support the use of biotechnology for human medicine.	62	2.00	0.87
I support the genetic engineering of feed crops.	62	1.94	0.83
I support the genetic engineering of food crops.	62	2.03	0.83
I support the genetic engineering of animals.	62	2.19	0.81
I support the use of biotechnology for environmental purposes.	61	1.79	0.61
Biotechnology should be a class taught by AG-ED Teachers.	62	1.97	0.72
Biotechnology should be a topic in an agriscience class.	61	1.72	0.69
I believe that local, state, and federal money should be spent to enhance the teaching of biotechnology?	62	1.79	0.66

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

The number and percentage of agricultural education teachers reporting their response to ten questions about biotechnology are reported in Table 8. Sixty-one percent of the teachers disagreed with the statement that cloning was morally wrong. Forty-seven percent strongly disagreed with the statement that cross breeding was morally wrong.

Forty-seven percent of the teachers supported the use of genetic engineering for feed and food crops and animals. Eighty-two percent agreed and strongly agreed that agricultural education teachers should teach the topic of biotechnology. Eighty-nine percent agreed and strongly agreed that biotechnology should be a topic taught in an agriscience class.

Table 8

Frequencies of Biotechnology Attitudes

Topics	Strongly Agree		Agree		Disagree		Strongly Disagree	
	f	%	f	%	f	%	f	%
Cloning living organisms is morally wrong.	6	9.7	10	16.1	38	61.3	7	11.3
Cross breeding to produce hybrids is morally wrong.	4	6.5	13	21.0	16	25.8	29	46.8
I support the use of biotechnology for human medicine.	19	30.6	28	45.2	11	17.7	4	6.5
I support the genetic engineering of feed crops.	20	32.3	29	46.8	10	16.1	3	4.8
I support the genetic engineering of food crops.	17	27.4	29	46.8	13	21.0	3	4.8
I support the genetic engineering of animals.	12	19.4	29	46.8	18	29.0	3	4.8
I support the use of biotechnology for environmental purposes.	19	30.6	36	58.1	6	9.7	1	1.6
Biotechnology should be a class taught by AG-ED Teachers.	15	24.2	36	58.1	9	14.5	2	3.2
Biotechnology should be a topic in an agriscience class.	24	38.7	31	50.0	5	8.1	1	1.6
I believe that local, state, and federal money should be spent to enhance the teaching of biotechnology?	20	32.3	36	58.1	5	8.1	1	1.6

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

The biotechnology attitudes reported by teachers were correlated with the key demographic variables. Table 9 displays the magnitude and significance between the responses to the ten statements about biotechnology and the demographics areas of years of experience, owning a farm, owning an agribusiness and degree held.

There was a negligible relationship (Kendall's tau-c) between years of teaching experience and six of the ten biotechnology statements. There was a low relationship (Kendall's tau-c) between years of teaching experience and the remaining four statements of: "Biotechnology should be a class taught by Ag-Ed teachers" (.24), "Biotechnology should be a topic in an agriscience class" (.14), "I support the use of biotechnology for environmental purposes" (.12), and "Cloning living organisms is morally wrong" (.11).

The statement, "Biotechnology should be a class taught by Ag-Ed teachers" was significant at the .01 level. Of the teachers that had eleven years or less of teaching experience, 96% strongly agreed or agreed that agricultural education teachers should be teaching biotechnology.

There was a negligible relationship (Cramer's V) between owning a farm and four of the six biotechnology statements. There was a low relationship (Cramer's V) between owning a farm and the following statements: "I support the use of genetic engineering for animals" (.28), "Biotechnology should be a topic in an agriscience class" (.22), "I believe that local, state, and federal money should be spent to enhance the teaching of biotechnology" (.18), and "I support the use of biotechnology for environmental purposes" (.15). A moderate relationship (Cramer's V) existed between owing a farm and the statements, "I support the use of genetic engineering of food crops" (.37) and "I support the use of genetic engineering of feed crops" (.31). The

statement "I support the use of genetic engineering of food crops" was significant at the .05 level. Ninety-five percent of the teachers that did not own a farm supported the use of genetic engineering for food crops.

A low relationship (Cramer's V) existed between owning an agribusiness and nine of the ten biotechnology statements. A moderate relationship (Cramer's V) existed between owning an agribusiness and the statement, "Biotechnology should be a topic in an agriscience class" (.44). This same statement was significant at the .01 level. Of the teachers that owned an agribusiness, 100% strongly agreed or agreed that biotechnology should be a topic taught in an agriscience class.

A low relationship (Cramer's V) existed between highest degree held and the following biotechnology statements: "Cross breeding to produce hybrids is morally wrong" (.29), "I believe that local, state, and federal money should be spent to enhance the teaching of biotechnology" (.27), and "Biotechnology should be a topic in an agriscience class" (.26). A moderate relationship (Cramer's V) existed between highest degree held and six of the ten biotechnology statements. A substantial relationship (Cramer's V) existed between the highest degree held and the statement, "Cloning living organisms is morally wrong" (.55). This relationship was significant at the .01 level. Of the teachers that held a master's degree or higher, 89.6% did not feel that cloning was morally wrong. The relationship between highest degree and the statement, "I support the use of biotechnology for environmental purposes" was significant at the .05 level. Ninety percent of teachers that held a bachelor's degree support the use of biotechnology for environmental purposes.

Table 9

Relationships Between Key Demographic Areas and Biotechnology Attitudes

Topics	Years Exp. (Kendall's tau-c)		Own Farm (Cramer's V)		Own Agribusiness (Cramer's V)		Degree Held (Cramer's V)	
Cloning living organisms is morally wrong.	0.11		0.07		0.14		0.55	**
Cross breeding to produce hybrids is morally wrong.	0.07		0.1		0.24		0.29	
I support the use of biotechnology for human medicine.	-0.07		0.06		0.18		0.3	
I support the genetic engineering of feed crops.	0.01		0.31		0.15		0.36	
I support the genetic engineering of food crops.	0.01		0.37	*	0.22		0.42	
I support the genetic engineering of animals.	-0.02		0.28		0.25		0.31	
I support the use of biotechnology for environmental purposes.	0.12		0.15		0.22		0.42	*
Biotechnology should be a class taught by AG-ED Teachers.	0.24	**	0.06		0.17		0.32	
Biotechnology should be a topic in an agriscience class.	0.14		0.22		0.44	**	0.26	
I believe that local, state, and federal money should be spent to enhance the teaching of biotechnology?	0.06		0.18		0.29		0.27	

* = significant at .05 level

** = significant at .01 level

Biotechnology Teaching Attitudes

Table 10 contains the mean levels for the attitudes of agricultural education teachers in the area of teaching biotechnology. Teachers were asked to respond to ten statements that all started with, "It is my job to…"

"Teach high school students about biotechnology" (M=1.94) was the only statement that had a mean below 2.00 indicating that teachers agreed that it was their job to teach high school students about biotechnology. Teachers also agreed that it was their job to "educate farmers and agriculturists about biotechnology (M=2.06), "involve students in biotechnology related SAEs" (M=2.11), "develop instructional materials and lesson plans on biotechnology" (M=2.11), "educate public policy makers about biotechnology" (M=2.31), and "educate consumers about biotechnology" (M=2.47). Teachers disagreed that it was their job to "conduct biotechnology research" (M=2.74) and develop publications about biotechnology (M=2.79).

Table 10

Means and Standard Deviations for Biotechnology Teaching Attitudes (n=62)

It is my job to…	f	M	SD
develop publications about biotechnology.	62	2.79	0.68
conduct biotechnology research.	62	2.74	0.79
sponsor meetings related to biotechnology.	62	2.60	0.66
distribute publications about biotechnology.	62	2.52	0.78
educate consumers about biotechnology.	62	2.47	0.72
educate public policy makers about biotechnology	62	2.31	0.69
develop instructional materials and lesson plans on biotechnology	62	2.11	0.55
involve students in biotechnology related SAEs.	62	2.11	0.52
educate farmers and agriculturists about biotechnology	62	2.06	0.60
teach high school students about biotechnology	62	1.94	0.57

1=Strongly Agree
2=Agree
3=Disagree
4=Strongly Disagree

Table 11 contains the number and percentage of agricultural education teachers reporting their responses to the ten statements concerning their responsibility with biotechnology. Ninety percent strongly agreed or agreed that it was their job to teach high school students about biotechnology. Eighty-two percent strongly agreed or agreed that it was their job to educate farmers and agriculturists about biotechnology. Seventy-one percent of the teachers strongly disagreed or disagreed that it was their job to develop publications about biotechnology. Sixty-two percent strongly disagreed or disagreed that conducting biotechnology research was their job.

Table 11

Frequencies of Biotechnology Teaching Attitudes

It is my job to…	Strongly Agree		Agree		Disagree		Strongly Disagree	
	f	%	f	%	f	%	f	%
teach high school students about biotechnology	11	17.7	45	72.6	5	8.1	1	1.6
develop instructional materials and lesson plans on biotechnology.	5	8.1	46	74.2	10	16.1	1	1.6
educate farmers and agriculturists about biotechnology.	8	12.9	43	69.4	10	16.1	1	1.6
educate public policy makers about biotechnology.	6	9.7	33	53.2	21	33.9	2	3.2
develop publications about biotechnology.	2	3.2	16	25.8	37	59.7	7	11.3
educate consumers about biotechnology.	4	6.5	29	46.8	25	40.3	4	6.5
sponsor meetings related to biotechnology.	4	6.5	19	30.6	37	59.7	2	3.2
conduct biotechnology research.	3	4.8	20	32.3	29	46.8	10	16.1
distribute publications about biotechnology.	5	8.1	26	41.9	25	40.3	6	9.7
involve students in biotechnology related SAEs.	4	6.5	48	77.4	9	14.5	1	1.6

1=Strongly Agree
2=Agree
3=Disagree
4=Strongly Disagree

Relationships Between Key Demographic Areas and Biotechnology Teaching Attitudes

The attitudes towards teaching biotechnology reported by teachers were correlated with the key demographic areas. Table 12 displays the magnitude and significance between the responses to the ten statements about their job concerning biotechnology and the demographics areas of years of experience, owing a farm, owning an agribusiness and degree held.

A negligible relationship (Kendall's tau-c) existed between years of teaching experience and all ten "It is my job to…" statements.

A low relationship (Cramer's V) existed between owning a farm and seven of the ten "It is my job to…" statements. There was a moderate relationship (Cramer's V) between owning a farm and the following "It is my job to…"statements: "involve students in biotechnology related SAEs" (.32), "teach high school students about biotechnology" (.32), and "educate farmers and agriculturists about biotechnology" (.31).

A low relationship (Cramer's V) existed between owning an agribusiness and six of the ten "It is my job to…" statements. A moderate relationship (Cramer's V) existed between owning an agribusiness and the following "It is my job to…"statements: "distribute publications about biotechnology" (.44), "teach high school students about biotechnology" (.38), "sponsor meetings related to biotechnology" (.36), and "involve students in biotechnology related SAEs" (.30). The "It is my job to…" statement, "distribute publications about biotechnology" was significant at the .01 level.

Seventy-two percent of the teachers that owned an agribusiness believed that it was the job of the agricultural education teacher to distribute publications about biotechnology.

The "It is my job to…" statement "teach high school students about biotechnology" was significant at the .05 level. Of the teachers that owned an agribusiness, 100% felt that it was the

job of the agricultural education teacher to teach biotechnology. The "It is my job to…" statement "sponsor meetings related to biotechnology" was significant at the .05 level.

A moderate relationship (Cramer's V) existed between highest degree held and the following "It is my job to…" statements: "educate public policy makers about biotechnology" (.44), "teach high school students about biotechnology" (.39), and "educate farmers and agriculturists about biotechnology" (.36). There was a substantial relationship (Cramer's V) between highest degree held and six of the ten "It is my job to…" statements. A very strong relationship (Cramer's V) existed between highest degree held and "It is my job to…" statement "develop publications about biotechnology" (.75). The following "It is my job to…" statements were significant at the .01 level: "conduct biotechnology research", "involve students in biotechnology related SAEs", "sponsor meetings related to biotechnology", and "develop publications about biotechnology." The following "It is my job to…" statements were significant at the .05 level: "develop instructional materials and lesson plant on biotechnology", "educate consumers about biotechnology," and "distribute publications about biotechnology." Sixty-nine percent of the teachers with master's degree did not feel that it was their job to conduct biotechnology research. Eighty-three percent of the teachers that held a master's degree or Ph.D. agreed it was the teacher's job to involve students in biotechnology related SAEs. Seventy percent of teachers with master's degrees did not feel that it was their job to sponsor biotechnology related meetings. Eighty-three percent of the teachers that held a master's degree did not agree that it was their job to develop biotechnology publications. Of the teachers with bachelor's degree, 87% felt that it was their job to develop instructional materials and lesson plans on biotechnology. Fifty-eight percent of the teachers that held a bachelor's degree agreed that it was the their job to educate consumers about biotechnology. Fifty percent of the teachers

that held a master's degree or Ph.D. believed it was their job to distribute biotechnology

publications.

Table 12

Relationships Between Key Demographic Areas and Biotechnology Teaching Attitudes

It is my job to…	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)		Degree Held (Cramer's V)	
teach high school students about biotechnology	-0.03	0.32	0.38	*	0.39	
develop instructional materials and lesson plans on biotech.	0.06	0.29	0.27		0.51	*
educate farmers and agriculturists about biotechnology.	-0.08	0.31	0.29		0.36	
educate public policy makers about biotechnology.	0.03	0.25	0.15		0.44	
develop publications about biotechnology.	0.05	0.28	0.16		0.75	**
educate consumers about biotechnology.	-0.11	0.21	0.18		0.51	*
sponsor meetings related to biotechnology.	-0.05	0.26	0.36	*	0.55	**
conduct biotechnology research.	-0.07	0.20	0.13		0.59	**
distribute publications about biotechnology.	-0.12	0.25	0.44	**	0.50	*
involve students in biotechnology related SAEs.	-0.09	0.32	0.30		0.54	**

* = significant at the .05 level

** = significant at the .01 level

Table 13 displays the means for biotechnology teaching implementation barriers.

Agricultural education teachers responded to a list of nine potential barriers to teaching

biotechnology.

Equipment (M=3.31) and instructional materials (M=3.1) had the highest mean scores,

indicating that teachers considered these to be moderate barriers to teaching biotechnology.

Classroom/lab space (M=2.98), time (M=2.95), textbooks (M=2.92), teacher knowledge

(M=2.87), and student academic ability (M=2.66) were also considered moderate barriers to

teaching biotechnology. Community support (M=2.00) and administration acceptance (M=2.00)

had the lowest mean score indicating that teachers considered these factors to be minor barriers

to teaching biotechnology.

Table 13

Means and Standard Deviations for Biotechnology Implementation Barriers (n=62)

Barrier	f	M	SD
Equipment	62	3.31	0.78
Instructional Materials	62	3.10	0.74
Classroom/Lab Space	62	2.98	0.93
Time	62	2.95	0.93
Textbooks	62	2.92	0.98
Teacher Knowledge	61	2.87	0.81
Student Academic Ability	62	2.66	0.89
Administration Acceptance	62	2.00	0.99
Community	62	2.00	0.94

1=Not at all
2=Minor
3=Moderate
4=Major

The number and percentage of agricultural education teachers reporting the barriers that they confront in teaching biotechnology is presented in Table 14.

As indicated in Table 14, teachers considered equipment, instructional materials, and classroom/lab space to be their greatest barriers for teaching biotechnology. Over 72% of the teachers considered these barriers to be moderate or major. Community support and administration acceptance, were two factors that most agricultural education teachers did not view as barriers to teaching biotechnology. Only 30.7% considered community support and 29.1% administration acceptance a moderate or major barrier.

Table 14

Frequencies of Biotechnology Implementation Barriers

Barrier	Not at all		Minor		Moderate		Major	
	f	%	f	%	f	%	f	%
Equipment	1	1.6	9	14.5	22	35.5	30	48.4
Instructional Materials	2	3.2	8	12.9	34	54.8	18	29.0
Textbooks	7	11.3	11	17.7	24	38.7	20	32.3
Student Academic Ability	7	11.3	17	27.4	28	45.2	10	16.1
Teacher Knowledge	2	3.2	18	29.0	27	43.5	14	22.6
Time	6	9.7	10	16.1	27	43.5	19	30.6
Classroom/Lab Space	5	8.1	12	19.4	24	38.7	21	33.9
Community	23	37.1	20	32.3	15	24.2	4	6.5
Administration Acceptance	24	38.7	20	32.3	12	19.4	6	9.7

1=Not at all
2=Minor
3=Moderate
4=Major

Relationships Between Key Demographic Areas and Biotechnology Barriers

The biotechnology teaching barriers reported by teachers were correlated with the key demographic areas. Table 15 displays the magnitude and significance between the responses to nine listed barriers to teaching biotechnology and the demographics areas of years of experience, owing a farm, owning an agribusiness and degree held.

A negligible relationship (Kendall's tau-c) existed between years of teaching experience and five of the nine biotechnology barriers. A low relationship (Kendall's tau-c) existed between years of teaching experience and the biotechnology barriers of instructional materials (.13), community (.13), and teacher knowledge (.20). A moderate relationship (Kendall's tau-c) existed between years of teaching experience and the biotechnology barrier of time (.30). The barrier of time was significant at the .01 level. Eighty-six percent of the teachers that did not own a farm reported time as a moderate or major barrier for teaching biotechnology. The biotechnology barrier of teacher knowledge was significant at the .05 level. Seventy-two percent of teachers with twelve years of experience or more reported that their knowledge of biotechnology was a moderate to major barrier to teaching biotechnology.

A negligible relationship (Cramer's V) existed between owning a farm and the biotechnology barriers of textbooks (.09) and instructional materials (.06). A low relationship (Cramer's V) existed between owning a farm and six of the nine biotechnology barriers. A moderate relationship (Cramer's V) existed between owning a farm and the barrier of time (.36).

A low relationship (Cramer's V) existed between owning an agribusiness and eight of the nine biotechnology barriers. A moderate relationship (Cramer's V) existed between owning and agribusiness and the barrier of equipment (.31).

A low relationship (Cramer's V) existed between highest degree held and the

biotechnology barriers of student academic ability (.26), community (.23), and teacher

knowledge (.19). A moderate relationship (Cramer's V) existed between six of the nine

biotechnology barriers. The barrier of classroom/lab space was significant at the .05 level. A

relatively similar percentage of teachers with bachelor's degrees (74.2%) and master's degrees

(72.4%) reported that classroom/lab space was a moderate or major barrier.

Table 15

Relationships Between Key Demographic Areas and Biotechnology Implementation Barriers

Barrier	Years Exp. (Kendall's tau-c)		Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)	
Equipment	-0.01		0.20	0.31	0.43	
Instructional Materials	0.13		0.06	0.17	0.42	
Textbooks	0.08		0.09	0.22	0.33	
Student Academic Ability	0.06		0.22	0.17	0.26	
Teacher Knowledge	0.21	*	0.20	0.19	0.19	
Time	0.30	**	0.36	0.23	0.35	
Classroom/Lab Space	0.00		0.18	0.14	0.49	*
Community	0.13		0.20	0.23	0.23	
Administration Acceptance	0.03		0.19	0.18	0.32	

* = significant at the .05 level
** = significant at the .01 level

Biotechnology Information

Table 16 displays the preferences of agricultural education teachers regarding how they would like to receive information about biotechnology. A list of nine sources of information was given for teachers to rate.

All nine sources of agriscience information had means ranging from 1.52 to 2.16 indicating that agricultural education teachers prefer receiving biotechnology information from all nine sources. The Internet (M=2.16) and slide sets/movies (M=2.16) had the highest means while workshops (M=1.52) had the lowest mean indicating the teachers would prefer having workshops on biotechnology more than any other information source.

Table 16

Means and Standard Deviations for Biotechnology Implementation - Receiving Information (n=62)

Information Source	f	M	SD
Slide sets/movies	62	2.16	0.85
Internet	62	2.16	0.73
CD-Rom	62	1.92	0.84
Computer Programs	62	1.85	0.76
Textbooks	62	1.85	0.62
Video Tapes	62	1.82	0.71
University courses	61	1.82	0.81
Lesson Plans	62	1.79	0.68
Workshops	62	1.52	0.59

1=Strongly Agree
2=Agree
3=Disagree
4=Strongly Disagree

The number and percent of teachers reporting the way that they would prefer to receive information about biotechnology is reported in Table 17.

All nine areas were rated desirable sources of receiving information. Twenty-nine percent of the teachers thought the Internet was not a desirable source and 32.3% felt that slide sets/movies were not desirable sources of biotechnology information.

Table 17

Frequencies of Biotechnology Implementation - Receiving Information

Information Source	Strongly Agree		Agree		Disagree		Strongly Disagree	
	f	%	f	%	f	%	f	%
Internet	10	16.1	34	54.8	16	25.8	2	3.2
Workshops	32	51.6	29	46.8	0	0.0	1	1.6
Video Tapes	20	32.3	35	56.5	5	8.1	2	3.2
Slide sets/movies	14	22.6	28	45.2	16	25.8	4	6.5
University courses	23	37.1	29	46.8	6	9.7	3	4.8
Lesson Plans	21	33.9	34	54.8	6	9.7	1	1.6
Textbooks	16	25.8	40	64.5	5	8.1	1	1.6
Computer Programs	22	35.5	28	45.2	11	17.7	1	1.6
CD-Rom	21	33.9	28	45.2	10	16.1	3	4.8

1=Strongly Agree
2=Agree
3=Disagree
4=Strongly Disagree

Relationships Between Key Demographic Areas and Biotechnology Information Sources

The information sources that agricultural education teachers prefer to receive information on biotechnology were correlated with the key demographic areas. Table 18 displays the magnitude and significance between the responses to nine listed information sources for biotechnology and the demographics areas of years of experience, owing a farm, owning an agribusiness and degree held.

A negligible relationship (Kendall's tau-c) existed between years of teaching experience and six of the nine biotechnology information sources. A low relationship (Kendall's tau-c) existed between years of teaching experience and the information sources of workshops (.12) and lesson plans (.10). A very strong relationship (Kendall's tau-c) existed between years of teaching experience and the Internet (.80).

A negligible relationship (Cramer's V) existed between owning a farm and the biotechnology information source of university courses (-.07). Seven of the nine information sources had a low relationship (Cramer's V) with owning a farm. A moderate relationship (Cramer's V) existed between owning a farm and CD-Rom (.30).

A negligible relationship (Cramer's V) existed between owning an agribusiness and the biotechnology information source of workshops (.07). A low relationship (Cramer's V) existed between five of the nine information sources. A moderate relationship (Cramer's V) existed between owning an agribusiness and the information sources of CD-Rom (.39), computer programs (.33), and university courses (.33). The information source of CD-Rom was significant at the .05 level. Seventy-nine percent of the teachers that did not own an agribusiness responded that they would prefer biotechnology information on CD-ROM.

A low relationship (Cramer's V) existed between highest degree held and six of nine biotechnology information sources. A moderate relationship (Cramer's V) existed between highest degree held and the information sources of Internet (.37), slide sets/movies (.33), and lesson plans (.30).

Table 18

Relationships Between Key Demographic Areas and Biotechnology Implementation - Receiving Information

	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
Information Source				
Internet	0.80	0.15	0.13	0.37
Workshops	0.12	0.14	0.07	0.18
Video Tapes	-0.11	0.14	0.15	0.19
Slide sets/movies	0.05	0.17	0.17	0.33
University courses	-0.02	0.07	0.33	0.21
Lesson Plans	0.10	0.11	0.19	0.30
Textbooks	-0.01	0.10	0.22	0.27
Computer Programs	0.04	0.22	0.33	0.23
CD-Rom	0.06	0.30	0.39	0.26

* = significant at the .05 level
** = significant at the .01 level

Knowledge of Agriscience

The agriscience knowledge mean rating reported by teachers is located in Table 19. All twelve areas of agriscience had means above 3.00. The topics of soil science (M=3.87), animal and vet science (M=3.75), horticulture (M=3.72), agricultural mechanics/engineering (M=3.65), botany/plant science (M=3.62), and crop science (M=3.62) had the highest means, indicating that teachers rated themselves as "applied, knowledgeable" on these topics. The topics of forestry science (M=3.48), environmental science (M=3.41), aquaculture (M=3.35), hydroponics (M=3.27), food science (M=3.27), and plant pathology (M=3.08) had means between 2.51 and 3.50 indicating that teachers perceived themselves as having "read about, possess some knowledge" about these topics. Soil science (M=3.87) had the highest mean value. Plant pathology (M=3.08) had the lowest mean value.

Table 19

Means and Standard Deviations for Agriscience Knowledge (n=62)

Topics	f	M	SD
Soil Science	61	3.87	0.34
Animal and Vet Science	61	3.75	0.43
Horticulture	60	3.72	0.49
Agriculture Engineering/Mechanics	60	3.65	0.61
Botany/Plant Science	61	3.62	0.55
Crop Science	60	3.62	0.56
Forestry Science	61	3.48	0.65
Environmental Science	59	3.41	0.67
Aquaculture	60	3.35	0.76
Hydroponics	60	3.27	0.8
Food Science	59	3.27	0.72
Plant Pathology	60	3.08	0.81

1=No knowledge
2=Heard about, but very little knowledge
3=Read about, possess some knowledge
4=Applied, knowledgeable

The number and percent of agricultural education teachers reporting their level of knowledge in twelve agriscience areas is reported in Table 20.

Hydroponics and Plant Pathology were the only two subjects that had one person indicate that they had no knowledge. Twenty-four percent of the teachers said they had heard and read about, but had very little knowledge about animal and vet science, while 75% said they had applied and were knowledgeable about animal and vet science. Eighty-six percent indicated they had applied and were knowledgeable about soil science.

Table 20

Frequencies of Agriscience Knowledge

Topics	No Knowledge		Little Knowledge		Some Knowledge		Knowledgeable	
	f	%	f	%	f	%	f	%
Soil Science	0	0.0	0	0.0	8	12.9	53	85.5
Botany/Plant Science	0	0.0	2	3.2	19	30.6	40	64.5
Hydroponics	1	1.6	10	16.1	21	33.9	28	45.2
Aquaculture	0	0.0	10	16.1	19	30.6	31	50.0
Animal and Vet Science	0	0.0	15	24.2	0	0.0	46	74.2
Forestry Science	0	0.0	5	8.1	22	35.5	34	54.8
Environmental Science	0	0.0	6	9.7	23	37.1	30	48.4
Agriculture Engineering/Mechanics	0	0.0	4	6.5	13	21.0	43	69.4
Food Science	0	0.0	9	14.5	25	40.3	25	40.3
Plant Pathology	1	1.6	14	22.6	24	38.7	21	33.9
Horticulture	0	0.0	1	1.6	15	24.2	44	71.0
Crop Science	0	0.0	2	3.2	19	30.6	39	62.9

1=No knowledge
2=Heard about, but very little knowledge
3=Read about, possess some knowledge
4=Applied, knowledgeable

Agriscience Teaching Methods Used

The number and percent of agricultural education teachers reporting the teaching methods

by which they teach agriscience topics is found in Table 21.

Twenty-seven percent of the teachers reported that they do not teach aquaculture.

Twenty-four percent indicated that they did not teach food science. Twenty-one percent reported

that they did not teach hydroponics. In eight of the twelve areas, 50% or more of the teachers

indicated that their students had applied what they learned. In all of the agriscience areas, 50% or

more of the teachers used lecture/discussion to deliver the material.

Table 21

Frequencies of Agriscience Teaching Methods

Topics	Don't Teach		Lecture/Discussion		Demonstration		Student Applied		Problem Solving	
	f	%	f	%	f	%	f	%	f	%
Soil Science	3	4.8	42	67.7	42	67.7	44	71.0	40	64.5
Botany/Plant Science	2	3.2	41	66.1	38	61.3	37	59.7	32	51.6
Hydroponics	13	21.0	35	56.5	26	41.9	26	41.9	21	33.9
Aquaculture	17	27.4	38	61.3	28	45.2	28	45.2	22	35.5
Animal and Vet Science	6	9.7	41	66.1	38	61.3	37	59.7	32	51.6
Forestry Science	8	12.9	41	66.1	31	50.0	37	59.7	29	46.8
Environmental Science Agriculture	6	9.7	43	69.4	24	38.7	31	50.0	24	38.7
Engineering/Mechanics	7	11.3	39	62.9	42	67.7	43	69.4	39	62.9
Food Science	15	24.2	33	53.2	22	35.5	23	37.1	17	27.4
Plant Pathology	11	17.7	35	56.5	18	29.0	17	27.4	15	24.2
Horticulture	6	9.7	43	69.4	42	67.7	40	64.5	39	62.9
Crop Science	9	14.5	39	62.9	29	46.8	31	50.0	26	41.9

Relationships Between Key Demographic Areas of Agriscience Level of Knowledge

The level of agriscience knowledge was correlated with the key demographic variables. Table 22 displays the magnitude and significance between the knowledge levels of the twelve agriscience topics and the demographics areas of years of experience, owing a farm, owning an agribusiness and degree held.

A negligible relationship (Kendall's tau-c) existed between years of teaching experience and five of the twelve agriscience topics. A low relationship (Kendall's tau-c) existed between years of teaching experience and the remaining agriscience topics of: environmental science (.25), botany/plant science (.21), animal and vet science (.21), food science (.17), aquaculture (.13), soil science (.13), and hydroponics (.12). The agriscience topics of botany/plant science and environmental science were significant at the .05 level. Seventy-five percent of the teachers with 15 years of experience or more indicated that they had applied and were knowledgeable about botany and plant science. Sixty percent of the teachers with eight years of experience or more reported that they had applied and were knowledgeable about environmental science.

A negligible relationship (Cramer's V) existed between owning a farm and the agriscience topics of botany/plant science (.07), animal and vet science (-.013), and soil science (-.179). A low relationship (Cramer's V) existed between owning a farm and seven of the twelve agriscience topics. A moderate relationship (Cramer's V) existed between owning a farm and food science (.33) and environmental science (.30). The relationship between owning a farm and the topic of food science was significant at the .05 level.

A negligible relationship (Cramer's V) existed between owning an agribusiness and the agriscience topics of soil science (.08) and animal and vet science (.02). A low relationship (Cramer's V) existed between owning an agribusiness and seven of the twelve agriscience topics.

A moderate relationship (Cramer's V) existed between owning an agribusiness and plant pathology (.32), forestry science (.32), and horticulture (.30). The topic of forestry science was significant at the .05 level. Seventy-seven percent of the teachers that owned an agribusiness indicated that they had applied and were knowledgeable about forestry science.

A negligible relationship (Cramer's V) existed between highest degree held and the agriscience topic of soil science (.06). The remaining eleven topics had a low relationship (Cramer's V) with highest degree held.

Table 22

Relationships Between Key Demographic Areas and Agriscience Knowledge

Topics	Years Exp. (Kendall's tau-c)		Own Farm (Cramer's V)		Own Agribusiness (Cramer's V)		Degree Held (Cramer's V)
Soil Science	0.13		-0.18		0.08		0.06
Botany/Plant Science	0.21	*	0.07		0.15		0.2
Hydroponics	0.12		0.14		0.26		0.28
Aquaculture	0.13		0.12		0.14		0.17
Animal and Vet Science	0.2		-0.01		0.02		0.12
Forestry Science	0.02		0.18		0.32	*	0.19
Environmental Science	0.25	*	0.3		0.22		0.18
Agriculture							
Engineering/Mechanics	-0.02		0.25		0.18		0.27
Food Science	0.17		0.33	*	0.25		0.23
Plant Pathology	0.17		0.19		0.32		0.24
Horticulture	0.03		0.14		0.3		0.16
Crop Science	0.11		0.19		0.2		0.27

* = significant at the .05 level

** = significant at the .01 level

Table 23 reports the means of agricultural education teachers reporting their knowledge of science topics. Seven key science areas were given for teachers to evaluate their knowledge level.

Biology (M=3.7) had the highest mean value, indicating that teachers perceived themselves as "applied, knowledgeable" in this area of science. Microbiology (M=2.33) had the lowest mean value, indicating that teachers perceived themselves as "heard about, but very little knowledge" in this area of science. Chemistry (M=3.21), environmental science (M=3.21), genetics (M=2.90), and geology (M=2.89) had mean values indicating that teachers had "took classes, possess some knowledge" in these areas of science. Physics (M=2.75) had a mean value that indicated that teachers had "heard about, but very little knowledge" in this area of science.

Table 23

Means and Standard Deviations for Science Knowledge (n=62)

Topics	f	M	SD
Biology	61	3.7	0.53
Chemistry	61	3.21	0.55
Environmental Science	61	3.20	0.7
Genetics	61	2.90	0.81
Geology	61	2.89	0.82
Physics	61	2.75	0.72
Microbiology	60	2.33	0.82

1=No knowledge
2=Heard and read about, but very little knowledge
3=Took classes, possess some knowledge
4=Applied, knowledgeable

Table 24 indicates the number and percentage of agricultural education teachers reporting their knowledge level of science. In six of seven science topics, over 60% of the teachers indicated they had taken classes and possessed some knowledge or had applied and were knowledgeable.

Table 24

Frequencies of Science Knowledge

Topics	No Knowledge		Little Knowledge		Some Knowledge		Knowledgeable	
	f	%	f	%	f	%	f	%
Chemistry	0	0.0	4	6.5	40	64.5	17	27.4
Biology	0	0.0	2	3.2	14	22.6	45	72.6
Physics	2	3.2	19	30.6	32	51.6	8	12.9
Environmental Science	0	0.0	10	16.1	29	46.8	22	35.5
Microbiology	10	16.1	23	37.1	24	38.7	3	4.8
Genetics	3	4.8	14	22.6	30	48.4	14	22.6
Geology	4	6.5	12	19.4	32	51.6	13	21

1=No Knowledge
2=Heard about, but very little knowledge
3=Read about, possess some knowledge
4=Applied, knowledgeable

Relationships Between Key Demographics and Level of Science Knowledge

The level of science knowledge was correlated with the key demographic areas. Table 25 displays the magnitude and significance between the knowledge levels of the seven science topics and the demographics areas of years of experience, owing a farm, owning an agribusiness and degree held.

A negligible relationship (Kendall's tau-c) existed between years of teaching experience and the knowledge of science topics of genetics (.08), biology (.06), and geology (.02). A low relationship (Kendall's tau-c) existed between years of teaching experience and knowledge of environmental science (.25), chemistry (.21), physics (.20), and microbiology (.17).

The topic of environmental science was significant at the .05 level. Sixty percent of the teachers that had only heard about and had very little knowledge about environmental science had seven years of experience or less.

A low relationship (Cramer's V) existed between all seven of the science topics and owning a farm. The statements ranged from .11 to .24.

A negligible relationship (Cramer's V) existed between five of the seven science topics and owning an agribusiness. A low relationship (Cramer's V) existed between owning an agribusiness and the science topics of microbiology (.17) and physics (.14).

A low relationship (Cramer's V) existed between highest degree held and four of the seven science topics. A moderate relationship (Cramer's V) existed between highest degree held and geology (.38) and genetics (.36). A very strong relationship (Cramer's V) existed between highest degree held and microbiology (.74). The topic of microbiology was significant at the .01 level. Sixty-five percent of the agricultural education teachers that had no knowledge or had only heard about, but possessed very little knowledge, held their BS degree.

Table 25

Relationships Between Key Demographic Areas and Science Knowledge

	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
Topics				
Chemistry	0.21	0.19	0.06	0.28
Biology	0.06	0.16	0.10	0.20
Physics	0.20	0.21	0.14	0.27
Environmental Science	0.25 *	0.21	0.10	0.17
Microbiology	0.17	0.14	0.17	0.74 **
Genetics	0.08	0.24	0.07	0.36
Geology	0.02	0.11	0.06	0.38

* = significant at the .05 level

** = significant at the .01 level

Agriscience Workshops/Classes Attended

Agricultural education teachers were asked how many agriscience classes or workshops they had attended since college graduation. Sixty-seven percent indicated that they had attended six or more agriscience classes or workshops. Thirty-three percent indicated that they had attended five or less agriscience classes or workshops.

Science Classes/Workshops

Agricultural education teachers were asked how many science classes or workshops they had attended since college graduation. Fifty-five percent indicated that they had never attended a science class or workshop. Twenty-four percent of the teachers had attended one or two science classes or workshops. Twenty-one percent indicated that they had attended three or more science classes and workshops.

Attitudes Toward Agriscience

Agricultural education teachers were asked seven questions to determine their attitudes toward agriscience. The statement, "WV agriculture education programs should teach only agriscience courses, had a mean of 3.0 indicating that the teachers did not agree with this statement. The statements, "All WV agriculture education programs should teach agriscience courses" (M=1.38) and "WV agricultural education teachers should have the option to be dual certified in science and Ag-Ed."(M=1.46) had means below 1.50 indicating that teachers strongly agreed with these statements. The remaining statements had mean values between 1.58 and 2.02 indicating that the teachers agreed with the statements. The mean values are recorded in Table 26.

Table 26

<u>Means and Standard Deviations for Agriscience Attitudes</u>
<u>(n=62)</u>

Topics	<u>f</u>	<u>M</u>	SD
WV agriculture education programs should teach only agriscience courses.	60	3.00	0.84
Agriscience courses are equally enriched with science concepts across WV.	59	2.02	0.96
WV agriculture education teachers should be dual certified in science and AgEd.	59	1.86	0.82
Agriscience should be taught at the middle school level.	60	1.70	0.77
WV agriscience courses should receive science credit.	59	1.58	0.62
WV agriculture education teachers should have the option to be dual certified in science and AgEd.	59	1.46	0.60
All WV agriculture programs should teach agriscience courses.	60	1.38	0.61

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

The number and percentage of agricultural education teachers reporting their responses to seven statements about agriscience is reported in Table 27. Ninety percent of the teachers strongly agreed or agreed that "All WV agriculture education programs should teach agriscience courses." Ninety-four percent of the teachers strongly agreed or agreed that "WV agriculture education teachers should have the option to be dual certified in science and Ag-Ed." Ninety-two percent of the teachers strongly agreed or agreed that "WV agriscience courses should receive science credit." Seventy-nine percent of the teachers strongly disagreed or disagreed with the statement "WV agriculture education programs should teach only agriscience courses."

Table 27

Frequencies of Agriscience Attitudes

Statements	Strongly Agree		Agree		Disagree		Strongly Disagree	
	f	%	f	%	f	%	f	%
All WV agriculture programs should teach agriscience courses.	41	66.1	15	24.2	4	6.5	0	0
Agriscience should be taught at the middle school level.	28	45.2	23	37.1	8	12.9	1	1.6
WV agriculture programs should teach only agriscience courses.	5	8.1	6	9.7	33	53.2	16	25.8
WV agriscience courses should receive science credit.	28	45.2	29	46.8	1	1.6	1	1.6
Agriscience courses are equally enriched with science concepts across WV.	21	33.9	21	33.9	12	19.4	5	8.1
WV agriculture teachers should be dual certified in science and AgEd.	23	37.1	22	35.5	13	21.0	1	1.6
WV agriculture teachers should have the option to be dual certified in science and AgEd.	34	54.8	24	38.7	0	0	1	1.6

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

Relationships Between Key Demographic Areas and Agriscience Attitudes

The responses to seven agriscience statements by agricultural education teachers were correlated with the key demographic areas. The magnitude and significance between the seven statements and the demographic areas of years of experience, owning a farm, owning an agribusiness and highest degree held is displayed in Table 28.

A negligible relationship (Kendall's tau-c) existed between years of experience and all seven agriscience attitude statements. The statement "WV agriculture programs should teach only agriscience courses" was significant at the .01 level. Eighty percent of the respondents that strongly agreed with the statement "WV agriculture education programs should teach only agriscience courses" had twenty-two years of teaching experience or more.

A low relationship (Cramer's V) existed between owning a farm and six of the seven agriscience attitude statements. A moderate relationship (Cramer's V) existed between owning a farm and the statement "Agriscience should be taught at the middle school level" (.33).

A low relationship (Cramer's V) existed between owning an agribusiness and six of the seven agriscience attitude statements. A moderate relationship (Cramer's V) existed between owning an agribusiness and the statement "WV agriculture education teachers should have the option to be dual certified in science and Ag-Ed" (.35).

A low relationship (Cramer's V) existed between highest degree held and six of the seven agriscience attitude statements. A substantial relationship (Cramer's V) existed between highest degree held and the statement "WV agriculture education programs should teach only agriscience courses" (.53). This statement was also significant at the .01 level. Eighty-seven percent of agriculture education teachers holding their BS degree strongly agreed or agreed with the statement "Agriscience should be taught at the middle school level."

Table 28

Relationships Between Key Demographic Areas and Agriscience
Attitudes

	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
Topics				
All WV agriculture education programs should teach agriscience courses.	0.05	0.10	0.20	0.24
Agriscience should be taught at the middle school level.	0.01	0.33	0.22	0.22
WV agriculture education programs should teach only agriscience courses.	-0.25 **	0.18	0.25	0.53 **
WV agriscience courses should receive science credit.	-0.03	0.14	0.27	0.29
Agriscience courses are equally enriched with science concepts across WV.	0.02	0.16	0.19	0.28
WV agriculture education teachers should be dual certified in science and AgEd.	-0.14	0.26	0.35	0.28
WV agriculture education teachers should have the option to be dual certified in science and AgEd.	-0.02	0.11	0.14	0.20

* = significant at the .05 level
** = significant at the .01 level

Agriscience Teaching Attitudes

Table 29 contains the mean levels for the attitudes of agricultural education teachers in the area of teaching agriscience. Teachers had to respond to ten statements that started with. "It is my job to…"

Six of the ten statements had mean values ranging from 1.73 to 2.45 indicating that the teachers agreed with these statements. Teachers strongly agreed with the following "It is my job to…" statements: "to teach high school students about agriscience"(M=1.35), "to involve students in agriscience related SAEs" (M=1.45), and "to develop instructional materials and lesson plans on agriscience" (M=1.50). Teachers disagreed with the "It is my job to…" statement, "develop publications about agriscience"(M=2.52).

Table 29

Means and Standard Deviations for Agriscience Teaching Attitudes (n=62)

It is my job to…	f	M	SD
develop publications about agriscience.	60	2.52	0.83
to conduct agriscience research	60	2.45	0.89
to distribute publications about agriscience	60	2.23	0.79
to educate consumers about agriscience	60	2.22	0.78
to sponsor meeting related to agriscience	60	2.22	0.76
to educate public policy makers about agriscience	60	2.05	0.79
to educate farmers and agriculturists	60	1.73	0.69
to develop instructional materials and lesson plans on agriscience	60	1.50	0.54
to involve students in agriscience related SAEs	60	1.45	0.59
to teach high school students about agriscience	60	1.35	0.52

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

Table 30 contains the number and percentage of agricultural education teachers reporting their responses to the ten statements concerning their responsibility with agriscience. Ninety-five percent of the teachers strongly agreed or agreed that it was their job to teach high school students about agriscience. Ninety-five percent strongly agreed or agreed that it was their job to develop instructional materials and lesson plans on agriscience. Ninety-two percent strongly agreed or agreed that it was their job to involve students in agriscience related SAEs. Eighty-three percent strongly agreed or agreed that it was their job to educate farmers and agriculturists about agriscience. Fifty-eight percent of the agricultural education teachers strongly disagreed or agreed that it was their job to develop publications about agriscience. Fifty-three percent strongly disagreed or disagreed that it was their job to conduct agriscience research.

Table 30

Frequencies of Agriscience Teaching Attitudes

	Strongly Agree		Agree		Disagree		Strongly Disagree	
It is my job to…	f	%	f	%	f	%	f	%
Teach high school students about agriscience.	40	64.5	19	30.6	1	1.6	0	0.0
Develop instructional materials and lesson plans on agriscience.	31	50.0	28	45.2	1	1.6	0	0.0
Educate farmers and agriculturists about agriscience.	24	38.7	28	45.2	8	12.9	0	0.0
Educate public policy makers about agriscience.	16	25.8	26	41.9	17	27.4	1	1.6
Develop publications about agriscience.	9	14.5	15	24.2	32	51.6	4	6.5
Educate consumers about agriscienece.	11	17.7	27	43.5	20	32.3	2	3.2
Sponsor meetings related to agriscience.	12	19.4	23	37.1	25	40.3	0	0.0
Conduct agriscience research.	11	17.7	16	25.8	28	45.2	5	8.1
Distribute publications about agriscience.	11	17.7	26	41.9	21	33.9	2	3.2
Involve students in agriscience related SAEs.	36	58.1	21	33.9	3	4.8	0	0.0

1=Strongly agree

2=Agree

3=Disagree

4=Strongly disagree

Relationships Between Key Demographic Areas and Agriscience Teaching Attitudes

The agriscience teaching attitudes reported by teachers were correlated with the key demographic areas. The magnitude and significance between the ten agriscience responsibilities and the demographic areas of year of experience, owning a farm, owning an agribusiness, and highest degree held is displayed in Table 31.

A negligible relationship (Kendall's tau-c) existed between years of experience and all ten teaching attitude statements. The "It is my job to…" statement "to educate public policy makers about agriscience" was significant at the .01 level. Eighty-seven percent of the agricultural education teachers that strongly agreed with the "It is my job to…" statement "to educate public policy makers about agriscience" had fifteen years of experience or more.

A low relationship (Cramer's V) existed between owning a farm and six of the ten agriscience teaching attitude statements. A moderate relationship (Cramer's V) existed between owning a farm and the following "It is my job to…" statements: "conduct agriscience research" (.43), "develop publications about agriscience" (.40), "distribute publications about agriscience" (.34), and "educate consumers about agriscience" (.30).

The relationship between "It is my job to…" statement "conduct agriscience research and owning a farm was significant at the .01 level and the relationship between "develop publications about agriscience" and owning a farm was significant at the .05 level. Fifty percent of those teachers that owned a farm as opposed to 35% of those that did not own a farm, strongly agreed or agreed that it was their job to conduct agriscience research. Sixty percent of the teachers that owned a farm disagreed that it was their job to develop publications about agriscience.

A low relationship (Cramer's V) existed between owning an agribusiness and all ten "It is my job to…" statements.

A low relationship (Cramer's V) existed between highest degree held and five of the ten "It is my job to…" statements. A moderate relationship (Cramer's V) existed between highest degree held and the following "It is my job to…" statements: "educate consumers about agriscience" (.45), "distribute publications about agriscience" (.40), "develop publications about agriscience" (.37), "conduct agriscience research" (.32), and "educate farmers and agriculturists about agriscience" (.30).

Table 31

Relationships Between Key Demographic Areas and Agriscience Teaching Attitudes

	Years Exp. (Kendall's tau-c)		Own Farm (Cramer's V)		Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
It is my job to…						
teach high school students about agriscience.	-0.05		0.21		0.10	0.17
develop instructional materials and lesson plans on agriscience.	-0.12		0.10		0.12	0.20
educate farmers and agriculturists about agriscience.	-0.20		0.07		0.09	0.30
educate public policy makers about agriscience.	-0.26	**	0.22		0.15	0.29
develop publications about agriscience.	-0.13		0.40	*	0.17	0.37
educate consumers about agriscienece.	-0.12		0.30		0.15	0.45
sponsor meetings related to agriscience.	-0.17		0.18		0.16	0.27
conduct agriscience research.	-0.08		0.43	**	0.28	0.32
distribute publications about agriscience.	-0.45	**	0.34		0.18	0.40
involve students in agriscience related SAEs.	0		0.17		0.08	0.17

* = significant at the .05 level

** = significant at the .01 level

Implementation of Agriscience

The means for barriers of agriscience implementation is displayed in Table 32.

Agricultural education teachers responded to a list of nine potential barriers of teaching

agriscience.

All nine barriers were considered to be minor. Their mean values ranged from 1.79 to

2.41. Classroom/Lab space (M=2.41) had the highest mean, while administration acceptance

(M=1.79) had the lowest mean.

Table 32

Means and Standard Deviations for Agriscience Implementation Barriers (n=62)

Barrier	f	M	SD
Classroom/Lab Space	61	2.41	0.97
Equipment	61	2.34	0.96
Instructional Materials	61	2.34	0.89
Time	61	2.23	0.86
Textbooks	61	2.18	0.96
Student Academic Ability	60	2.17	0.85
Teacher Knowledge	61	1.98	0.96
Community	61	1.89	0.88
Administration Acceptance	61	1.79	0.92

1=Not at all
2=Minor
3=Moderate
4=Major

Table 33 contains the number and percentage of agricultural education teachers reporting

their responses to the nine barriers of teaching agriscience. Seventy-nine percent of the

agricultural education teachers indicated that administration acceptance of teaching agriscience

was not at all or a minor barrier. Seventy-six percent of the teachers indicated that community

support of teaching agriscience was not at all or a minor barrier. Forty-five percent of the

agricultural education teachers indicated that classroom/lab space was a moderate or major

barrier to teaching agriscience. Thirty-nine percent of the teachers indicated that instructional

material on agriscience was a moderate or major barrier. Thirty-five percent of the teachers

indicated that agriscience equipment was a moderate or major barrier.

Table 33

Frequencies of Agriscience Implementation Barriers

Barrier	Not at all		Minor		Moderate		Major	
	f	%	f	%	f	%	f	%
Equipment	11	17.7	28	45.2	12	19.4	10	16.1
Instructional Materials	10	16.1	27	43.5	17	27.4	7	11.3
Textbooks	16	25.8	25	40.3	13	21.0	7	11.3
Student Academic Ability	13	21.0	28	45.2	15	24.2	4	6.5
Teacher Knowledge	24	38.7	18	29.0	15	24.2	4	6.5
Time	12	19.4	28	45.2	16	25.8	5	8.1
Classroom/Lab Space	12	19.4	21	33.9	19	30.6	9	14.5
Community	24	38.7	23	37.1	11	17.7	3	4.8
Administration Acceptance	29	46.8	20	32.3	8	12.9	4	6.5

1=Not at all
2=Minor
3=Moderate
4=Major

Relationships Between Key Demographic Areas and Agriscience Barriers

The agriscience teaching barriers reported by teachers were correlated with the key

demographic areas. Table 34 displays the magnitude and significance between the ten agriscience

barriers and the demographic areas of year of experience, owning a farm, owning an

agribusiness, and highest degree held.

A negligible relationship (Kendall's tau-c) existed between years of experience and seven

of the nine agriscience barriers. A low relationship (Kendall's tau-c) existed between years of

experience and the barrier of time (.21) and administration acceptance (.11).

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The barrier of time was significant at the .05 level. Of the teachers that indicated time was a major barrier, 100% had fifteen years of experience or more.

A low relationship (Cramer's V) existed between owning a farm and eight of the nine agriscience barriers. A moderate relationship (Cramer's V) existed between owning a farm and the agriscience barrier of administration acceptance (.37). This barrier was also significant at the .05 level.

A negligible to low relationship (Cramer's V) existed between owning an agribusiness and all nine agriscience barriers. They ranged from .07 to .28.

A low relationship (Cramer's V) existed between highest degree held and five of the nine agriscience barriers. A moderate relationship (Cramer's V) existed between highest degree held and the barriers of time (.45), textbooks (.34), equipment (.30), and administration acceptance (.30).

Table 34

Relationships Between Key Demographic Areas and Agriscience Implementation Barriers

	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
Barrier				
Equipment	-0.04	0.18	0.27	0.30
Instructional Materials	0.01	0.14	0.28	0.26
Textbooks	-0.07	0.18	0.07	0.34
Student Academic Ability	0.00	0.17	0.15	0.23
Teacher Knowledge	0.10	0.27	0.17	0.21
Time	0.21 *	0.16	0.15	0.45
Classroom/Lab Space	-0.09	0.24	0.08	0.29
Community	-0.01	0.28	0.28	0.24
Administration Acceptance	0.11	0.37 *	0.13	0.30

* = significant at the .05 level

** = significant at the .01 level

The means that agricultural education teachers reported on how they would prefer to receive agriscience information is reported in Table 35. Teachers responded to a list of nine sources of information for agriscience.

Agricultural education teachers agreed that they would prefer to receive information about agriscience from eight of the nine information sources. Those information sources had mean values that ranged from 1.70 to 2.02. The information source of workshops (M=1.46) had the highest mean, indicating that agricultural education teaches strongly agree with receiving information about agriscience through workshops.

Table 35

Means and Standard Deviations for Agriscience Implementation - Receiving Information (n=62)

Information Source	f	M	SD
Internet	61	2.02	0.83
Slide sets/movies	61	2.00	0.84
CD-Rom	61	1.90	0.81
Computer Programs	61	1.84	0.69
Lesson Plans	61	1.80	0.65
University Courses	61	1.79	0.82
Textbooks	61	1.74	0.60
Video Tapes	61	1.70	0.64
Workshops	61	1.46	0.62

1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

The number and percentage of agricultural education teachers reporting their responses to the nine information sources of agriscience is contained in Table 36. Ninety-five percent of the agricultural education teachers strongly agreed or agreed that they prefer to receive agriscience information from workshops. Ninety-three percent of the teachers strongly agreed or agreed that they prefer to receive agriscience information from textbooks. Ninety-two percent of the teachers strongly agreed or agreed that they prefer to receive agriscience information from videotapes. Twenty-four percent of the agricultural education teachers strongly disagreed or disagreed that they prefer to receive agriscience information from slide sets/movies. Twenty-three percent of the teachers strongly disagreed or disagreed that they prefer to receive agriscience information from the Internet.

Table 36

Frequencies of Agriscience Implementation - Receiving Information

Information Source	Strongly Agree f	%	Agree f	%	Disagree f	%	Strongly Disagree f	%
Internet	16	25.8	32	51.6	9	14.5	4	6.5
Workshops	36	58.1	23	37.1	1	1.6	1	1.6
Video Tapes	23	37.1	34	54.8	3	4.8	1	1.6
Slide sets/movies	18	29.0	28	45.2	12	19.4	3	4.8
University courses	24	38.7	30	48.4	3	4.8	4	6.5
Lesson Plans	19	30.6	36	58.1	5	8.1	1	1.6
Textbooks	20	32.3	38	61.3	2	3.2	1	1.6
Computer Programs	19	30.6	34	54.8	7	11.3	1	1.6
CD-Rom	20	32.3	30	48.4	8	12.9	3	4.8

1=Strongly agree
2=Agree
3=Disagree
4=Strongly Disagree

Relationships Between Key Demographic Areas and Receiving Agriscience Information

The preferred sources of agriscience information reported by teachers were correlated with the key demographic areas. Table 37 displays the magnitude and significance between the nine sources of agriscience information and the demographic areas of year of experience, owning a farm, owning an agribusiness, and highest degree held.

A negligible relationship (Kendall's tau-c) existed between years of experience and six of the nine sources of agriscience information. A low relationship (Kendall's tau-c) existed between years of experience and the information sources of lesson plans (.15), the Internet (.11), and workshops (.10).

A negligible relationship (Cramer's V) existed between owning a farm and the agriscience information source of university courses (.06). A low relationship (Cramer's V) existed between owning a farm and eight of the nine sources of agriscience information.

A low relationship (Cramer's V) existed between owning and agribusiness and all nine agriscience information sources. They ranged from .11 to .29.

A low relationship (Cramer's V) existed between highest degree held and five of the nine agriscience information sources. A moderate relationship (Cramer's V) existed between highest degree held and the agriscience information sources of lesson plans (.42), slide sets/movies (.38), computer programs (.31), and university courses (.30).

Table 37

Relationships Between Key Demographic Areas and Agriscience Implementation - Receiving Information

	Years Exp. (Kendall's tau-c)	Own Farm (Cramer's V)	Own Agribusiness (Cramer's V)	Degree Held (Cramer's V)
Information Source				
Internet	0.11	0.29	0.11	0.28
Workshops	0.10	0.24	0.11	0.23
Video Tapes	-0.06	0.12	0.24	0.23
Slide sets/movies	0.05	0.22	0.29	0.38
University courses	0.04	0.06	0.16	0.30
Lesson Plans	0.15	0.16	0.23	0.42
Textbooks	-0.13	0.11	0.19	0.24
Computer Programs	0.00	0.28	0.23	0.31
CD-Rom	0.07	0.15	0.24	0.25

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of the study was to provide information to the state supervisor of agricultural education and teacher educators that may be useful in modifying undergraduate course requirements and in planning in-service workshops and graduate courses to enhance teacher knowledge. To accomplish this purpose, 95 West Virginia agricultural education teachers were surveyed to ascertain their knowledge, attitudes, and implementation of biotechnology and agriscience.

The primary objective of this study was to describe West Virginia agricultural education teachers' attitudes toward and knowledge level of biotechnology and agriscience as well as activities which demonstrate implementation of biotechnology and agriscience. A secondary objective was to determine relationships that exist between selected demographic teacher variables and agriscience attitudes and knowledge levels.

Research Questions

The following questions provided direction for the study:

1. What are the attitudes of West Virginia agricultural education teachers toward biotechnology and agriscience?

2. What level of knowledge and understanding is demonstrated by West Virginia agricultural education teachers regarding biotechnology and agriscience?

3. What teaching methods do West Virginia Agricultural Education teachers use when teaching biotechnology and agriscience?

4. What is the perceived role of the agricultural education teacher with regard to biotechnology?

5. What barriers do agricultural education teachers face when they teach agriscience and biotechnology concepts and problems?

6. What relationships exist between selected teacher demographic variables and biotechnology attitudes and knowledge levels?

7. How do West Virginia agricultural education teachers prefer to receive biotechnology and agriscience information?

Responses of West Virginia agricultural education teachers are summarized in the following pages. Results of the data analysis are presented in the following areas: demographics of the sample group; frequency, mean, and standard deviation of biotechnology and agriscience knowledge, teaching method used, attitudes, and implementation; frequency and percent of biotechnology and agriscience knowledge, attitudes, and implementation; and relationships between biotechnology and agriscience knowledge, attitudes, and implementation and key demographic areas.

Data obtained were analyzed at West Virginia University using the Statistical Package for Social Sciences for Windows (SPSS). Data were analyzed using frequencies, percentages, means, Kendall's tau-c coefficient and Cramer's V coefficient.

Demographics of the Sample Group

The population of this study consisted of WV agricultural education teachers employed during the 2000-2001 school year. Each teacher was asked how many years they had taught, what was the highest degree they held, whether they operated a farm or an agribusiness, and what were the courses they were currently teaching.

An existing study and questionnaire conducted by Kirby (1990) in North Carolina was modified for this research. The instrument used in the Kirby study was used to establish content validity of the data collection instrument.

A panel of experts, consisting of agricultural education teachers serving on the West Virginia Program and Policy committee, was used to pilot test the instrument. They were administered the questionnaire and the data were used to establish the instrument's reliability. Cronbach's alpha is the most widely used reliability tool. The reliability of the instrument was found to be .9026. Sixty-two of the 95 agricultural education teachers returned the instrument resulting in a 65% response rate.

Biotechnology Level of Knowledge Summary and Conclusions

West Virginia agricultural education teachers were asked to rate their knowledge level on eighteen topics of biotechnology. In all cases a score of 1 = no knowledge, 2 = heard about, but very little knowledge, 3 = read about, possess some knowledge, and 4 = applied, knowledgeable.

West Virginia agricultural education teachers perceived themselves as having only "heard about, but very little knowledge" on the topics of bioremediation, electrophoresis, human genomics, transgenic species, recombinant DNA, and microbial biotechnology. The teachers perceived themselves as having "read about, possess some knowledge" on the topics of gene splicing, environmental biotechnology, food biotechnology, genetic engineering, genetically modified food, cloning, biotechnology ethics, plant tissue culture, resistant plant species, hybridization, and growth hormones. Animal reproduction was the only biotechnology topic that West Virginia agricultural education teachers perceived themselves as having "applied, knowledgeable."

A substantial relationship existed between operating a farm and the topic of growth hormones. Slightly more than half of the teachers responding who operated a farm perceived themselves as having "applied, knowledgeable" about the topic of growth hormones. A moderate relationship existed between operating an agribusiness and the topic of animal reproduction. Slightly more than 90% of the teachers who operated an agribusiness perceived themselves as having "applied, knowledgeable" on the topic of animal reproduction. A substantial relationship existed between highest degree held and the biotechnology topics of transgenic species, recombinant DNA, gene splicing, and electrophoresis. Agricultural education teachers with a master's degree or higher perceived themselves as more knowledgeable on the topics of recombinant DNA and electrophoresis than teachers with bachelors degrees. Those with bachelor's degrees perceived themselves as more knowledgeable on the topic of gene splicing than did those who possessed advanced degrees.

Conclusions

Based upon the biotechnology level of knowledge that West Virginia agricultural education teacher's reported, the following conclusions can be drawn:

- Teachers perceive themselves as having more knowledge on biotechnology topics that have traditionally been associated with agriculture (animal reproduction, hybridization) and less knowledge on topics that are associated with other fields (environmental biotechnology, human genomics)

- Teachers that operate a farm or agribusiness perceive themselves as more knowledgeable than those that do not on several biotechnology topics.

Summary and Conclusions of Biotechnology Teaching Methods Used

West Virginia agricultural education teachers were asked to indicate how they taught the eighteen biotechnology topics. They could select as many as applied of the following teaching techniques: don't teach, lecture/discussion, demonstration, student applied, and problem solving.

Slightly more than half of the teachers taught nine of the eighteen biotechnology topics. The topics that were taught the most were topics that teachers perceived themselves as being more knowledgeable about. Lecture/discussion was used most with the topics that were taught. Teachers teaching biotechnology topics used the teaching methods of demonstration, student application, and problem solving very little. When these techniques were used, it was with areas in which teachers perceived themselves as being more knowledgeable.

Conclusions

Based on the data provided by West Virginia agricultural education teachers on the biotechnology teaching methods used, the following conclusions can be drawn:

- Teachers are teaching some biotechnology topics in their programs.

- Teachers are more likely to teach the biotechnology topics found in agriculture and tend not to include areas outside of agriculture.

- Teachers are more likely to teach biotechnology topics that they perceive themselves as having more knowledge than those topics in which they perceive themselves as having less knowledge about.

Summary and Conclusions for Biotechnology Classes/Workshops Attended

The West Virginia agricultural education teachers were asked how many biotechnology classes/workshops they have attended since college graduation. More than half had never attended a biotechnology class/workshop.

Conclusions

Based on the information provided by West Virginia agricultural education teachers on how many biotechnology classes/workshops they had attended, the following conclusions can be drawn:

- Teachers are not attending biotechnology classes/workshops when available, or

- Biotechnology classes/workshops are not being offered for teachers to attend.

Summary and Conclusions for Attitudes toward Biotechnology

The attitudes possessed by West Virginia agricultural education teachers of biotechnology were divided into two sections. In the first section, teachers responded to ten biotechnology issue questions. In the second section, teachers responded to ten statements that were preceded by "It is my job to…" In all cases a 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree.

In the first section, teachers agreed with almost all of the biotechnology statements. Teachers disagreed with two statements, "Crossbreeding to produce hybrids is morally wrong" and "Cloning living organisms is morally wrong." Teachers believed that biotechnology should be a class taught by agricultural education teachers and that it should be a topic in an agriscience class. A low relationship existed between years of experience and the statement, "Biotechnology should be a class taught by agricultural education teachers." Teachers with less experience (eleven years or less) agreed with this statement more than those with more experience (more than eleven years). A moderate relationship existed between operating a farm and the statement,

"I support the use of genetic engineering of food crops." Nearly all of the teachers that did not operate a farm, agreed with this statement. A moderate relationship existed between operating an agribusiness and the statement, "Biotechnology should be a topic in an agriscience class." The entire group of teachers that operated an agribusiness, agreed with this statement. A substantial relationship existed between highest degree held and the statement, "Cloning living organisms is morally wrong." Nearly 90% of the teachers with a master's degree or higher did not feel that cloning was morally wrong.

In the second attitude section, teachers agreed that it was their job to do more than half of the biotechnology responsibilities. Teachers did not feel that it was their job to, distribute publications about biotechnology, sponsor meetings related to biotechnology, conduct biotechnology research, and develop publications about biotechnology. A moderate relationship existed between operating an agribusiness and the job of distributing publications about biotechnology and teaching high school students about biotechnology. Almost three-fourths of the teachers that operated an agribusiness believed it was their job to distribute publications about biotechnology and the entire group of agribusiness operating teachers believed it was their job to teach high school students about biotechnology. A moderate to substantial relationship existed between highest degree held and several biotechnology responsibilities. More than 60% of the teachers that held their master's degree or higher, did not feel that it was job to conduct biotechnology research, sponsor biotechnology-related meetings, or develop biotechnology publications. More than 50% of the teachers that held their bachelor's degree believed that it was their job to develop instructional materials and lesson plans on biotechnology and educate consumers about biotechnology.

<u>Conclusions</u>

Based on the data collected from the West Virginia agricultural education teachers concerning their attitudes about biotechnology, the following conclusions can be drawn:

- Teachers support the use of biotechnology in today's world.

- Agricultural education teachers believe that they should teach biotechnology courses and topics.

- It is more likely that teachers with less experience will teach biotechnology.

- It is more likely that teachers that operate an agribusiness will teach biotechnology.

- Teachers believe more that a biotechnology responsibility applies to their job if it involves educating people and involving students.

- Teachers do not believe that biotechnology responsibility applies to their job if it involves outside activities that do not involve students and educating people.

- It is more likely that teachers that operate an agribusiness will perform biotechnology responsibilities that do not involve students and educating people.

- It is more likely that teachers with a bachelor's degree will perform more biotechnology responsibilities than those with a master's degree or higher.

<u>Summary and Conclusions of Implementation of Biotechnology</u>

Information on how West Virginia agricultural education teachers implement biotechnology was divided into two sections. In the first section, teachers rated nine barriers to teaching biotechnology. In all cases a 1 = not at all, 2 = minor, 3 = moderate, and 4 = major. In the second section, teachers rated how they would prefer to receive biotechnology information. In all cases a 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree.

In the first implementation section, teachers felt that there were many barriers to teaching biotechnology. Biotechnology equipment was the greatest barrier for teachers teaching biotechnology. They did not feel that administration acceptance and community support was a barrier. A low relationship existed between years of experience and the barrier of teacher knowledge. Nearly three-fourths of the teachers, with twelve years of experience or more, considered teacher knowledge to be a barrier.

In the second section, teachers agreed that they would prefer to receive information from many different sources. Teachers preferred workshops on biotechnology to all other information sources.

Conclusions

Based on the information provided by West Virginia agricultural education teachers in the biotechnology implementation sections, the following conclusions can be drawn:

- The greatest barriers that exist for teachers teaching biotechnology are in the areas of equipment, instructional materials, and lab space.

- Teachers that have been teaching longer have missed instruction on the fairly new topics of biotechnology and consider teacher knowledge a barrier.

- It is highly likely that if biotechnology workshops were available, teachers would participate.

Summary and Conclusions of Knowledge of Agriscience

West Virginia agricultural education teachers were asked to rate their knowledge level on twelve topics of agriscience. In all cases a score of 1 = no knowledge, 2 = heard about, but very little knowledge, 3 = read about, possess some knowledge, and 4 = applied, knowledgeable.

Teachers perceived themselves having "read about, possess some knowledge", about the

topics of plant pathology, food science, hydroponics, aquaculture, environmental science, and forestry science. Teachers perceived themselves as "applied, knowledgeable" about the topics of crop science, botany/plant science, agriculture mechanics/engineering, horticulture, animal and vet science, and soil science. The topic of soil science had nearly 90% of the teachers perceiving themselves as knowledgeable. A low relationship existed between years of experience and the agriscience areas of botany/plant science and environmental science. Three-fourths of the teachers with more teaching experience perceived themselves as more knowledgeable about botany and plant science. Almost two-thirds of the teachers with more teaching experience perceived themselves as more knowledgeable in the area of environmental science. A moderate relationship existed between operating an agribusiness and the topic of forestry science. A little more than three-fourths of the teachers that operated an agribusiness perceived themselves as more knowledgeable about this topic.

Conclusions

Based on the information provided by West Virginia agricultural education teachers in the area of knowledge level of agriscience, the following conclusions can be drawn:

- Teachers perceive themselves as knowledgeable about agriscience.

- It is more likely that teachers with more teaching experience are more knowledgeable about several agriscience topics.

Summary and Conclusions of Agriscience Teaching Methods Used

West Virginia agricultural education teachers were asked to indicate how they taught the 12 agriscience topics. They could select as many as applied of the following teaching techniques: don't teach, lecture/discussion, demonstration, student applied, and problem solving.

The majority of the teachers reported teaching most of the agriscience topics. The areas of aquaculture, food science, and hydroponics were taught the least. The areas of soil science and botany/plant science were taught the most. In all the agriscience topics, more than half of the teachers used lecture/discussion and in more than half of the agriscience topics, teachers indicated that students applied what they learned.

Conclusions

- It is more likely that teachers will teach the areas of agriscience that they are more knowledgeable about.

- Teachers teaching agriscience use a variety of teaching methods.

- Students apply what they learn in agriscience.

Summary and Conclusions of Agriscience Workshops/Classes Attended

The West Virginia agricultural education teachers were asked how many agriscience classes/workshops they have attended since college graduation. About two-thirds of the teachers indicated that they had attended six or more agriscience classes or workshops. All had attended at least one agriscience class or workshop.

Conclusions

Based on the information provided by West Virginia agricultural education teachers concerning the number of agriscience classes/workshops that they have attended, the following conclusion can be drawn:

- Teachers participate in workshops/classes offered on agriscience.

Summary and Conclusions of Level of Science Knowledge

West Virginia agricultural education teachers were asked to rate their knowledge level on seven science topics. In all cases a score of 1 = no knowledge, 2 = heard and read about, but very

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little knowledge, 3 = took classes, possess some knowledge, and 4 = applied, knowledgeable.

Teachers perceived themselves as having "heard and read about, but very little knowledge" about the topic of microbiology. Teachers reported that they had "took classes, possess some knowledge" on the topics of physics, geology, genetics, environmental science, and chemistry. Teachers perceived themselves as "applied, knowledgeable" about the topic of biology. A low relationship existed between years of experience and the topic of environmental science. Almost two-thirds of the teachers with less experience perceived themselves as having very little knowledge about the topic. A very strong relationship existed between highest degree held and the topic of microbiology. A little less than two-thirds of the teachers that held their bachelor's degree had very little knowledge about the topic.

Conclusions

Based on the data provided by West Virginia agricultural education teachers on level of science knowledge, the following conclusion can be drawn:

- The majority of teachers perceive themselves as having scientific knowledge.

- It is more likely that teachers with more teaching experience are more knowledgeable about science.

- It is more likely that teachers with higher degrees are more knowledgeable about science.

Summary and Conclusions of Science Classes/Workshops Attended

The West Virginia agricultural education teachers were asked how many science classes/workshops they have attended since college graduation. Almost half of the teachers had attended at least one science class or workshop.

<u>Conclusions</u>

Based on the information provided by West Virginia agricultural education teachers concerning the number of science classes/workshops that they have attended, the following conclusion can be drawn:

- West Virginia agricultural education teachers are involving themselves with science opportunities.

<u>Summary and Conclusion of Attitudes Toward Agriscience</u>

The attitudes possessed by West Virginia agricultural education teachers of agriscience were divided into two sections. In the first section, teachers responded to seven agriscience issue questions. In the second section, teachers responded to ten statements that were preceded by "It is my job to…" In all cases a 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree.

In the first section, teachers agreed with every agriscience statement with the exception of one. Teachers did not agree with the statement, "WV agriculture education programs should teach only agriscience courses."

In the second section of agriscience attitudes, teachers strongly agreed it was their job to teach high school students about agriscience, to involve students in agriscience related SAEs, and to develop instructional materials and lesson plans on agriscience. The teachers agreed it was their job to do all but one of the agriscience responsibilities. Teachers disagreed that it was their job to develop publications about agriscience. A moderate relationship existed between operating a farm and the responsibility of conducting agriscience research and developing publications about agriscience. Slightly more than half of the teachers that operated a farm agreed that it was their job to conduct agriscience research, but almost two-thirds did not agree that it was their job to develop publications about agriscience.

<u>Conclusions</u>

Based on the information provided by West Virginia agricultural education teachers on their attitudes toward agriscience, the following conclusions can be drawn:

- Teachers do not feel that agriscience courses should be the only courses taught in an agricultural education program.

- It is unlikely that teachers will develop publications about agriscience.

<u>Summary and Conclusions of Implementation of Agriscience</u>

Information on how West Virginia agricultural education teachers implement agriscience was divided into two sections. In the first section, teachers rated nine barriers to teaching agriscience. In all cases a 1 = not at all, 2 = minor, 3 = moderate, and 4 = major. In the second section, teachers rated how they would prefer to receive agriscience. In all cases a 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree.

In the first section, teachers rated all nine barriers to teaching agriscience as minor. Classroom/lab space, equipment, and instructional materials were considered the most serious minor barriers to teaching agriscience. Administration acceptance and community support were the least serious minor barriers to teaching agriscience. A low relationship existed between years of experience and the barrier of time. All of the teachers, with fifteen years of experience or more, indicated time as a major barrier to teaching agriscience.

In the second section, teachers strongly agreed that workshops were the preferred information source for agriscience. Teachers agreed that they would prefer to receive agriscience information from all of the information sources provided.

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Conclusions

Based on the information provided by West Virginia agricultural education teachers on their attitudes toward agriscience, the following conclusions can be drawn:

- Teachers have overcome the barriers of teaching agriscience, but could still use assistance on equipment, classroom/lab space, and instructional materials.

- It is more likely that younger teachers will have more time to dedicate to overcoming the barriers and implementing agriscience.

Recommendations

In order to inform secondary agricultural educators and to improve secondary agriculture programs in West Virginia, the following recommendations are made to the West Virginia University Agricultural and Environmental Education faculty and the West Virginia Department of Education Agricultural Education staff based on the results of this study:

- This study needs to be replicated in its complete or modified form to teachers nationwide or regionally to determine if the findings differ significantly from those in this study. A study on just biotechnology or agriscience could be conducted separately.

- Offer support to high school agricultural education departments to implement biotechnology and other scientifically enhanced curriculum.

- Offer competitive grants for programs that want to implement biotechnology or agriscience topics into their curriculum.

- Offer more biotechnology and agriscience classes and workshops for teachers.

- Offer incentives to agricultural education teachers for developing science enriched agriculture curriculum and for becoming certified to teach science.

- Continue to pursue statewide science credit for agricultural education.

- Change undergraduate requirements of agricultural education majors by adding more science courses leading to a double certification in agricultural education and science.

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APPENDICES

APPENDICES A

Initial Letter to West Virginia Agricultural Education Teachers

Dear

       We are conducting a thesis study to determine the knowledge level, teaching methods used, attitudes, and implementation of biotechnology and agriscience. We are gathering information from all agricultural education instructors in West Virginia. The results of this research could be used to impact college course offerings, teacher workshops and in-services, and agricultural education curriculum.

       On the enclosed survey we have asked you to simply circle most of your responses. Although your participation is voluntary, we are asking you to please take a few minutes of your time to fill out the survey. Please answer every question that you feel comfortable answering. Please be assured that all information will be held completely confidential. You will notice a code number at the top right of the first page of the survey. This code will be used to facilitate the forwarding of additional mailings to you if necessary.

       Enclosed with the questionnaire is a self-addressed stamped envelope for your convenience. If we might have your response by February 10, 2001, we would be most appreciative.

       Thank you in advance for your cooperation.

Sincerely,

Jason E Hughes   Dr. Stacy A. Gartin
Graduate Student   Professor
Agricultural Education   Agricultural Education

APPENDICES B

Follow-up Letter to West Virginia Agricultural Education Teachers

February 21, 2001

Inside address

Dear

       We recently mailed you a survey concerning the thesis study we are conducting to determine the knowledge level, teaching methods used, attitudes, and implementation of biotechnology and agriscience.

       As of yet, we have not received your response. If you have responded let us thank you in advance. If not, please take a few minutes to fill out the enclosed survey. Your participation is voluntary, but your participation would be greatly appreciated.

       On a personal note, I realize that you do not have a lot of extra time, especially to fill out surveys. I would just ask you to keep in mind that you would be helping me reach a goal of obtaining my Master's Degree this semester. Your assistance would be **greatly appreciated.**

       Enclosed with the questionnaire is a self-addressed, return envelope for your convenience. If we might have your response by March 5, 2001, we would be most appreciative. Please feel free to fax the information to us at (304) 293-3752.

       Thank you in advance for your cooperation.

Sincerely,

Jason E. Hughes   Stacy A. Gartin
Graduate Student   Professor
Agricultural Education   Agricultural Education

APPENDICES C

Questionnaire

Attitudes, Knowledge, and Implementation of Biotechnology
and Agriscience by West Virginia Agricultural Education Teachers
Survey

Please circle your level of knowledge and teaching method used in the following areas of biotechnology using the following scale: (Note: On the teaching method, please circle all that apply.)

Topics	Level of Knowledge				Teaching Method Used				
	No knowledge	Heard about, but very little knowledge	Read about, possess some knowledge	Applied, Knowledgeable	Do not teach	Lecture/Discussion	Teacher Demonstration	Student Applied Problems/Problem Solving	
Recombinant DNA	1	2	3	4	1	2	3	4	5
Bioremediation	1	2	3	4	1	2	3	4	5
Gene Splicing	1	2	3	4	1	2	3	4	5
Genetic Engineering	1	2	3	4	1	2	3	4	5
Cloning	1	2	3	4	1	2	3	4	5
Transgenic species	1	2	3	4	1	2	3	4	5
Genetically modified food	1	2	3	4	1	2	3	4	5
Electrophoresis	1	2	3	4	1	2	3	4	5
Environmental Biotechnology	1	2	3	4	1	2	3	4	5
Food Biotechnology	1	2	3	4	1	2	3	4	5
Microbial Biotechnology	1	2	3	4	1	2	3	4	5
Hybridization	1	2	3	4	1	2	3	4	5
Plant Tissue Culture	1	2	3	4	1	2	3	4	5
Resistant plant species	1	2	3	4	1	2	3	4	5
Animal Reproduction	1	2	3	4	1	2	3	4	5
Growth Hormones (bST, pST)	1	2	3	4	1	2	3	4	5
Human Genomics	1	2	3	4	1	2	3	4	5
Biotechnology Ethics	1	2	3	4	1	2	3	4	5

How many biotechnology classes/workshops have you attended? _____

Attitudes toward Biotechnology

Please circle your response to the following statements using the following scale:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Cloning living organisms is morally wrong?	1	2	3	4
Cross breeding to produce hybrids is morally wrong?	1	2	3	4
I support the use of biotechnology for human medicine?	1	2	3	4
I support the genetic engineering of feed crops?	1	2	3	4
I support the genetic engineering of food crops?	1	2	3	4
I support the genetic engineering of animals?	1	2	3	4
I support the use of biotechnology for environmental purposes?	1	2	3	4
Biotechnology should be a class taught by AG-ED Teachers?	1	2	3	4
Biotechnology should be a topic in an agriscience class?	1	2	3	4
I believe that local, state, and federal money should be spent on teaching biotechnology?	1	2	3	4

Please circle your response to the following statements using the following scale:

It is my job to…	Strongly Agree	Agree	Disagree	Strongly Disagree
teach high school students about biotechnology	1	2	3	4
develop instructional materials and lesson plans on biotechnology.	1	2	3	4
educate farmers and agriculturists about biotechnology.	1	2	3	4
educate public policy makers about biotechnology.	1	2	3	4
develop publications about biotechnology.	1	2	3	4
educate consumers about biotechnology.	1	2	3	4
sponsor meetings related to biotechnology.	1	2	3	4
conduct biotechnology research.	1	2	3	4
distribute publications about biotechnology.	1	2	3	4
involve students in biotechnology related SAEs.	1	2	3	4

Implementation of Biotechnology

Please rate how the following would be a barrier to you teaching biotechnology:

Barrier	Not at all	Minor	Moderate	Major
Equipment	1	2	3	4
Instructional Materials	1	2	3	4
Textbooks	1	2	3	4
Student Academic Ability	1	2	3	4
Teacher Knowledge	1	2	3	4
Time	1	2	3	4
Classroom/Lab Space	1	2	3	4
Community	1	2	3	4
Administration Acceptance	1	2	3	4

Please circle your response to the following statements using the following scale:

I would prefer to receive biotechnology information from…	Strongly Agree	Agree	Disagree	Strongly Disagree
Internet	1	2	3	4
Workshops	1	2	3	4
Video Tapes	1	2	3	4
Slide sets/movies	1	2	3	4
University courses	1	2	3	4
Lesson Plans	1	2	3	4
Textbooks	1	2	3	4
Computer Programs	1	2	3	4
CD-Rom	1	2	3	4

Knowledge of Agriscience

Please circle your level of knowledge and teaching method used in the following areas of

Topics	Level of Knowledge				Teaching Method Used				
	No knowledge	Heard about, but very little knowledge	Read about, possess some knowledge	Applied, Knowledgeable	Do not teach	Lecture/Discussion	Teacher Demonstration	Student Applied	Problems/Problem Solving
Soil Science	1	2	3	4	1	2	3	4	5
Botany/Plant Science	1	2	3	4	1	2	3	4	5
Hydroponics	1	2	3	4	1	2	3	4	5
Aquaculture	1	2	3	4	1	2	3	4	5
Animal and Vet Science	1	2	3	4	1	2	3	4	5
Forestry Science	1	2	3	4	1	2	3	4	5
Environmental Science	1	2	3	4	1	2	3	4	5
Ag. Engineering/Mechanics	1	2	3	4	1	2	3	4	5
Food Science	1	2	3	4	1	2	3	4	5
Plant Pathology	1	2	3	4	1	2	3	4	5
Horticulture	1	2	3	4	1	2	3	4	5
Crop Science	1	2	3	4	1	2	3	4	5

Please circle your level of knowledge in the following areas of science using the following scale:

Subject	Level of Knowledge			
	No knowledge	Heard and read about, but very little knowledge	Took classes, possess some knowledge	Applied, Knowledgeable
Chemistry	1	2	3	4
Biology	1	2	3	4
Physics	1	2	3	4
Environmental Science	1	2	3	4
Microbiology	1	2	3	4
Genetics	1	2	3	4
Geology	1	2	3	4

How many agriscience classes/workshops have you attended since college graduation? _____

How many science classes/workshops have you attended since college graduation? _____

Attitudes toward Agriscience

Please circle your response to the following statements using the following scale:

	Strongly Agree	Agree	Disagree	Strongly Disagree
All WV ag. Programs should teach agriscience courses?	1	2	3	4
Agriscience should be taught at the middle school level?	1	2	3	4
WV ag. Programs should teach only agriscience courses?	1	2	3	4
WV agriscience courses should receive science credit?	1	2	3	4
Agriscience courses are equally enriched with science concepts across WV?	1	2	3	4
WV ag. Teachers should be dual certified in science and AgEd?	1	2	3	4
WV ag. Teachers should have the option to be dual certified in science and AgEd?	1	2	3	4

Please circle your rating of the following statements using the following scale:

It is my job to…	Strongly Agree	Agree	Disagree	Strongly Disagree
teach high school students about agriscience.	1	2	3	4
develop instructional materials and lesson plans on agriscience.	1	2	3	4
educate farmers and agriculturists about agriscience.	1	2	3	4
educate public policy makers about agriscience.	1	2	3	4
develop publications about agriscience.	1	2	3	4
educate consumers about agriscienece.	1	2	3	4
sponsor meetings related to agriscience.	1	2	3	4
conduct agriscience research.	1	2	3	4
distribute publications about agriscience.	1	2	3	4
involve students in agriscience related SAEs.	1	2	3	4

Implementation of Agriscience

Please rate how the following would be a barrier to you teaching agriscience.

Barrier

	Not at all	Minor	Moderate	Major
Equipment	1	2	3	4
Instructional Materials	1	2	3	4
Textbooks	1	2	3	4
Student Academic Ability	1	2	3	4
Teacher Knowledge	1	2	3	4
Time	1	2	3	4
Classroom/Lab Space	1	2	3	4
Community	1	2	3	4
Administration Acceptance	1	2	3	4

Please circle your response to the following statements using the following scale:

I would prefer to receive agriscience information from…	Strongly Agree	Agree	Disagree	Strongly Disagree
Internet	1	2	3	4
Workshops	1	2	3	4
Video Tapes	1	2	3	4
Slide sets/movies	1	2	3	4
University courses	1	2	3	4
Lesson Plans	1	2	3	4
Textbooks	1	2	3	4
Computer Programs	1	2	3	4
CD-Rom	1	2	3	4

Demographic Information

1. How many years have you taught agricultural education, counting this year? _____

2. Circle your highest degree?   BS   MS   PhD

3. Do you own or operate a farm? _____ Yes   _____ No

4. Do you own or operate an agribusiness?   _____ Yes   _____ No

5. In the space provided, please list all of the agricultural education classes that you are teaching this school year and indicate if they are year long (YL) or semester (S).

VITA

Jason E. Hughes

1992	Bachelor of Science Agricultural Education West Virginia University Morgantown, WV
1992	Substitute Teacher Grades 5-8 and 9-12
1993	Environmental Specialist West Virginia Department of Agriculture Pt. Pleasant, WV
1993	Agriscience Teacher Wood County Technical Center Parkersburg, WV
1996	Agriscience Teacher St. Marys High School St. Marys, WV
2001	Master of Science Agricultural Education West Virginia University Morgantown, WV